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PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

(*FOUNDED 1858.*)

VOLUME THE TWENTIETH,

1907-1908.

EDITED BY

HORACE WOOLLASTON MONCKTON.

(*Authors alone are responsible for the opinions and facts stated in their respective Papers.*)

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ADDENDA ET CORRIGENDA.

Page 36, line 39, for "Maurice Mancel Allorge" *read* "Maurice Marcel Allorge."

" 178, The date of the Excursion to Rochester, etc., was July 6th, and *not* July 9th as stated.

" 358, *Footnote.** *For* "See foot p. 376" *read* "See *post*, p. 376."

" 362, *Footnote.*† *For* "See foot p. 387" *read* "See *post*, p. 387."

" 369, lines 3 and 4, *for* "Since Forbes's day no President has been elected under 50" *read* "Since Forbes's day no President has been elected under 40, and during the last twenty years none under 50."

" 463, lines 27 and 35, *for* "chrysolite" *read* "chrysotile."

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PROCEEDINGS

OF THE

Geologists' Association.

EDITED BY

HORACE WOOLLASTON MONCKTON.

(Authors alone are responsible for the statements in their respective Papers.)

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(*Continued on page 3 of the Cover.*)

MAY 7

PROCEEDINGS
OF THE
GEOLOGISTS' ASSOCIATION.

THE RULES OF THE ASSOCIATION.

As revised at a Special General Meeting held on July 7th, 1893.

I.

The Society shall be called THE GEOLOGISTS' ASSOCIATION.

II.

The object of the Association shall be to facilitate the study of Geology and its allied sciences by the holding of Meetings for the reading of Papers and the delivery of Lectures, by Excursions, by the formation of a Library, by the publishing of Proceedings, and by such other means in furtherance of the above object as the Council may determine.

III.

The Association shall consist of Ordinary and Honorary Members, both Ladies and Gentlemen being eligible for election.

IV.

Members shall have the privilege of introducing two Visitors at the Ordinary Meetings and Excursions of the Association, except when otherwise ordered by the Council, and they shall be entitled to the use of the Library in accordance with the Library Regulations, and to receive a copy of the Circulars and Proceedings of the Association issued during their membership.

V.

Every Candidate for admission as an Ordinary Member shall be proposed by two or more Members, who shall sign a certificate in recommendation of such Candidate, setting forth his or her name and place of residence; the Proposer whose name stands first upon the certificate shall have personal knowledge of the Candidate, and shall certify to that effect upon the certificate.

VI.

The certificate of the Candidate shall be read at the Ordinary Meeting following the receipt of the same, and the Candidate shall be submitted for election at the succeeding Ordinary Meeting.

VII.

The method of voting for the election of Ordinary Members shall be as follows: the name shall be read from the Chair and the Candidate shall be declared duly elected unless a ballot is demanded, in which case one black ball in six shall exclude, but no such ballot shall be valid unless twelve Members shall have voted.

VIII.

Ordinary Members shall pay an Admission Fee of Ten Shillings, and (except in the case of Country Members elected previous to January, 1863) an Annual Subscription of Ten Shillings, and shall not be entitled to any of the rights or privileges of Membership until the Admission Fee and the first Annual Subscription shall have been paid.

IX.

Members may commute the Annual Subscription by a payment of Seven Pounds Ten Shillings (excepting those Members elected before November, 1893, who may commute the same by a payment of Five Pounds Five Shillings).

X.

The Annual Subscription shall become due on the 1st of January in each year; in the case of new Members, immediately after election, but the first Annual Subscription of Members elected during the months of November and December shall cover the year following that of their election.

XI.

Ordinary Members whose Annual Subscription is twelve months in arrear shall not be entitled to any of the rights or privileges of Membership; and any Member whose Annual Subscriptions are two years in arrear may be removed from the Association by the Council.

XII.

Any Member, whose conduct is, in the opinion of the Council, prejudicial to the interests of the Association, may be removed from the Association by the Council, by the vote of a majority of two-thirds present at a Meeting of the Council, on the Agenda paper of which the words "Removal of a Member" shall have appeared; provided that no Member may be so removed, unless due notice has been sent to him of the intention of the Council to proceed against him under this Rule, and of the nature of the charges made against him, and an opportunity has been afforded him of answering such charges, and of explaining his conduct to the satisfaction of the Council.

XIII.

The management of the Association shall be vested in a President, four Vice-Presidents, a Treasurer, one or more Secretaries, as the Council may from time to time determine, an Editor, a Librarian, and twelve other Members, who shall constitute a Council, to be elected annually at the Annual General Meeting by ballot; provided that the senior Vice-President, and the two senior Members of the Council who shall not have held during the preceding year any distinctive office, shall not be eligible for re-election as Vice-President, or as unofficial Members of the Council, respectively, until the next Annual General Meeting; and that the new Council shall contain at least four Members who were not Members of the Council during the preceding year.

XIV.

In case of a vacancy arising in any office of the Association, or in the Council, the Council shall have power to fill up such vacancy until the next Annual General Meeting of the Association.

XV.

The Members of the Council attending each Meeting of such Council shall sign their names in a book kept for the purpose; five Members shall form a quorum, except as otherwise provided in these Rules.

XVI.

The Council may be sub-divided into such committees as are desirable, and may associate Members not on the Council on any such committees.

XVII.

For the purpose of the legal protection of the property of the Association, all the funds, books, specimens, and other property of the Association shall be vested in three or more Trustees, who shall be Members of the Association, and shall be appointed by the Council; provided that the Council shall have power, by the vote of a majority of its whole number, to sell or otherwise dispose of any books, specimens, or other property as may seem to them advisable for the benefit of the Association.

XVIII.

Minutes shall be kept of the Meetings of the Association and of the Council, and the minutes of each Meeting shall be read as the first business of the next ensuing Meeting of the same kind.

XIX.

The Ordinary Meetings of the Association shall be held on the first Friday in each month (except during the months of August, September, and October) at eight o'clock in the evening, but the Council may alter the day and hour of Meeting.

XX.

The Council may, whenever they think fit, and they shall, upon a Requisition signed by not less than twelve Members, convene a Special General Meeting of the Association. One month's notice of the date and object of such Special General Meeting shall be given from the Chair, and a printed notice to the same effect shall be sent to each Member of the Association residing in the United Kingdom, not less than seven days before such Meeting; and no business shall be considered at such Meeting except that for which it was specially convened.

XXI.

The Accounts of the Association shall be made up to the 31st December in each year, and audited by two Auditors, who shall be appointed at the January Meeting; and the Balance-sheet shall be submitted, together with a Report of the general progress of the Association during the preceding year, to an Annual General Meeting, which shall be held at such hour before the Ordinary Meeting in February as the Council shall appoint.

XXII.

Persons of eminence in geological science, or who have done some special service to the Association, may be recommended by the Council for election as Honorary Members at the Annual General Meeting, and shall, upon being elected, have full rights and privileges of Membership, but the number of Honorary Members shall not exceed twenty.

XXIII.

A copy of these Rules shall be sent to each Member on election.

XXIV.

No Rule shall be altered except by a majority of votes of those present at a Special General Meeting convened for that purpose.

ORDINARY MEETING.

Friday, November 2nd, 1906.

R. S. Herries, M.A., V.P.G.S. President, in the Chair.

The following were elected members of the Association: Arthur Chichester Crookshank, Archibald Sanford.

The evening was then devoted to a Conversazione and the following is a list of the exhibitors and their exhibits;

The President: A representative collection of fossils from the Lias of Yorkshire, arranged according to zones.

The Director of the Geological Survey: Maps and Memoirs published by the Survey during the past year.

G. F. Brown: Fossils from the Chalk of Merstham, Epsom and Ashtead.

Rev. R. Ashington Bullen: Prehistoric remains from Harlyn Bay, Cornwall, and Foraminifera from the Pleistocene of Eastern Crete.

C. P. Chatwin and T. H. Withers: A series of fossils from the Chalk selected to show zonal variation.

G. E. Dibley: Fossils from the Chalk, including a set of 31 associated teeth of *Ptychodus decurrens* from the *Holaster subglobosus*-zone of Burham, Kent.

F. B. Edmonds: The Tolmên (picture), Constantine, Cornwall.

W. G. Fearnsides on behalf of Mr. T. O. Bosworth: Fossils from the Lower Chalk of Cambridge.

James Francis: Fossils from the Lias of the Yorkshire Coast.

J. W. Garnham: Specimens of worked rock-crystal, jade etc.

Prof. E. J. Garwood: Models and photographs of Ticino Lakes. Three-colour micro-photographs of sections of rocks and minerals.

Miss M. S. Johnston: Fossils from the Jurassic rocks of England and of Bavaria.

H. Kidner: Jet, Fossil wood, etc. from the Yorkshire Coast.

F. Lasham: Eolithic and Palæolithic Implements.

D. A. Louis: Minerals from Cornwall, and from Colorado, and, by special permission, the Presentation Portrait of Professor Judd, painted by T. Liddall Armitage.

Dr. H. C. Male: Pleistocene bones from a cave at Clevedon, with photographs.

E. T. Newton: Specimens collected on Excursions of the Association.

G. Potter: Portrait of Toulmin Smith, first President of the Association, and various prints of geological interest.

T. W. Reader: A series of Ammonites from the Lias.

Dr. A. E. Salter: Contoured map of the northern counties of England on a scale of 1-inch to 2 miles.

W. P. D. Stebbing: Rocks from Loch Spiggie, Shetland.

A. Beeby Thompson: Native Bitumens and other Petroleum products.

A. Todd-White: Palæolithic Implements, recently found at Leytonstone.

Miss E. Whitley: Lava and volcanic dust from the eruption of Vesuvius in 1906, with photographs, also Gabbros from the Saas Fée District.

A. H. Williams: Rocks from the Lizard and other Cornish localities.

W. Wright: Fossils from the Chalk of Surrey.

W. P. Young: Geological lantern slides, mainly from Lyme Regis and Whitby, also photographs to illustrate water-erosion.

R. & J. Beck, Ltd: Two Microscopes and Objects.

ORDINARY MEETING.

FRIDAY, DECEMBER 7TH, 1906.

R. S. HERRIES, M.A., V.P.G.S., President, in the Chair.

The following were elected members of the Association: Rev. Robert Percy Barron, Percy George Hamnall Boswell, Arthur L. Dixon, Harvey Collingridge, B.Sc., A.M.I.C.E., Christopher C. Fagg, Joseph Green, Paul Haas, D.Sc., Ph.D., William Henry Hamilton, William Hay, Miss K. M. Leeds, Henry Edward Newton, John Newton, Rev. Joseph Newton, Harold Tinker, Joseph Tunstall, Major A. R. Winsloe, R.E., Thomas John Woodrow, M. Yeatman-Wolff, F.Z.S.

The President referred to the death of the Rev. J. F. Blake, and said that the Council, at their Meeting on October 5th, had passed a motion of sympathy, and a copy of the resolution had been sent to the members of the family. He also announced that the Council, acting under Rule XIV, had, on October 5th, appointed Mr. E. T. Newton to be Vice-President in place of Rev. J. F. Blake, and Messrs. T. V. Holmes and W. Whitaker to be members of the Council to fill the vacancies caused by the deaths of the Rev. J. F. Blake and Mr. Percy Emary.

The President then said that the Association had recently suffered a further loss by the death of Mr. Thomas Leighton, which occurred very suddenly on November 11th, within a few days of that of his wife. Mr. Leighton had acted for several years as Excursion Secretary with great energy and success, doing all the work without the assistance of a committee. His wide knowledge of business matters had also been of great practical value to the Association. He then proposed the following resolution which had already been adopted by the Council:—"The Council and Members of the Geologists' Association having heard with much regret of the death of Mr. Thomas Leighton, for several years Excursion Secretary of the Association, beg to tender their sincere sympathy with his family in their bereavement."

The resolution was carried and ordered to be entered on the Minutes, and a copy sent to the family of the late Mr. Leighton.

The following paper was read:—"The Zones of the White Chalk of the English Coast, part V, The Isle of Wight." by Dr. Arthur W. Rowe, F.G.S. The paper was illustrated by lantern slides and diagrams.

At the conclusion of the Paper, Mr. C. Davies Sherborn described the diagrams which were exhibited. The President then expressed the thanks of the Association to the Author, and a discussion followed in which Mr. H. J. Osborne White and Mr. G. W. Young took part.

ORDINARY MEETING.

FRIDAY, JANUARY 4TH, 1907.

R. S. HERRIES, M.A., V.P.G.S., President, in the Chair.

The following were elected members of the Association: Albert Henry Hill, Alexander Frederick Hogg, M.A., Peter McIntyre, James Stephen Neil, Mrs. Dalton Pontifex.

Messrs. H. Kidner, F.G.S., and J. V. Elsden, F.G.S., were appointed Auditors of the Accounts of the Association for 1906.

A lecture was given by Horace Woollaston Monckton, V.P.L.S., F.G.S., entitled "On a Norwegian Snowfield and its Glaciers." It was illustrated by a series of lantern slides from photographs taken by the lecturer for the most part during the past summer showing views of the great Snowfield, Jostedalsbræ, and of the following Glaciers which flow down from it. Lundebræ, Mælkevoldbræ, Brigsdalsbræ, Kjendalsbræ, Suphellebræ, and Bojumsbræ.

The Lecture was followed by a discussion in which the President, Mr. G. W. Young, Mr. W. Whitaker, and Mr. Corcoran took part. Mr. Monckton briefly replied.

ANNUAL GENERAL MEETING.

FRIDAY, FEBRUARY 1ST, 1907.

R. S. HERRIES, M.A., V.P.G.S., President, in the Chair.

Messrs F. Nichols and F. Morey were appointed Scrutineers of the ballot.

The following report of the Council for the year 1906 was then read:

THE numerical strength of the Association on December 31st, 1906, was as follows:

Honorary Members.	15
Ordinary Members—	
a. Life Members (compounded).	169
b. Old Country Member (5s. Annual Subscription)	1
c. Other Members (10s. Annual Subscription)	434
Total	619

This shows an increase of twenty-five members as compared with the corresponding figures for the previous year, and it is noteworthy that this is the first time the Association has reached a membership of over 600.

During the year forty-nine new members were elected.

The Council regret that the Association has lost an unusually large number, no fewer than twelve, by death during the year. Amongst them were some of the oldest and best known of our members, including two members of the Council. The names are: Rev. J. F. Blake, Frank Chapman, Charles Baron Clarke, Henry Dewes, Percy Emary, George Frederick Harris, Thomas Leighton, Joseph Puckett, Arthur R. Rayden, George J. Smith, Charles Southwell, and James Wadeson.

Prof. J. F. Blake, M.A., F.G.S., died July 7th, 1906, aged 67 years. In him the Association has lost one of its most active and gifted members. A full obituary notice appears in the Geological Magazine for September, 1906, but the following particulars may be of interest. He was an Old Blue-Coat boy, and proceeding from Christ's Hospital to Caius College, Cambridge, he became 15th Wrangler in 1862 also taking first place in the Natural Science Tripos in the same year. He joined the Association in 1875, edited the PROCEEDINGS for 1881 and 1882, and was President for 1891-3. In 1895 the Lyell Medal was awarded to him by the Geological Society.

He was a man of untiring energy, and his geological works were very numerous, several important ones having been contributed to our PROCEEDINGS, amongst which may be particularly mentioned:

"On the Chalk of Yorkshire," vol. v, part 5.
"On the Classification of Rocks," vol. vi, part 9.
"The N.W. Highlands and their Teachings," vol. viii, part 8.
"The Volcanoes of Italy," vol. xi, part 4.
"Geology of Country between Redcar and Bridlington," vol. xii, part 4.
*"The Evolution and Classification of the Cephalopoda," vol. xii, part 7.
"Sketch of the Geology of Carnarvonshire and Anglesey," vol. xii, parts 9 and 10.
*"On the bases of the Classification of Ammonites," vol. xiii, part 2.

He also wrote reports of the many Excursions of which he was Director. He was a frequent exhibitor at the Annual Conversazione, and his death leaves a gap in the ranks of the Association which it will be hard to fill.

Charles Baron Clarke, M.A., F.R.S., F.L.S., F.G.S., joined the Association in 1897. Although taking considerable interest in Geology he was much better known as a botanist. He was a keen observer, and during a long residence in India he devoted his leisure to the study of the vegetation of the Far East, upon which he was recognised as an authority. For the last thirty years he paid particular attention to the Sedges (Cyperaceæ) and has left an immense amount of manuscript descriptions of this difficult family. He was President of the Linnean Society from 1894 to 1896. Despite his age (74 years) he was exceedingly active and frequently attended the Excursions of the Association, the last being to Ightham on July 21st, less than a month before his death, when he appeared to be in the best of health.

In Percy Emary, F.G.S., our late Secretary, the Association has lost a zealous and efficient officer. He joined in 1893, and was appointed Secretary in June, 1897, which post he held until his death in May last, at the early age of 38. During this long period of nearly nine years he gave unremitting attention to the onerous duties of the office. He was a member of the Clerical Staff of the Education Department of the London County Council, and was Assistant Lecturer on Geology at the Birkbeck Institute. He was elected a Fellow of the Geological Society in 1897. An appreciative notice by the President will be found in the PROCEEDINGS, vol. xix, p. 446.

George Frederick Harris, F.G.S., was elected in 1884, and served as a member of the Council in 1887. He had not of late attended many of the meetings of the Association, but his position as Lecturer on Geology at the Birkbeck Institute

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*Presidential Address.

brought him into close connection with many of our younger geologists. In conjunction with Mr. H. W. Burrows he wrote an exhaustive paper, "On the Eocene and Oligocene Beds of the Paris Basin," which was published as a separate paper by the Association. It is a work of patient research, and invaluable to anyone visiting the district (see also *Geol. Mag.*, September, 1906).

Thomas Leighton, F.G.S., who joined in 1886, was at one time, perhaps, the most active member of the Association. During the years 1890 to 1896 he acted as sole Excursion Secretary without the help of a Committee, a position that demanded an enormous amount of harassing work, which he cheerfully undertook and successfully carried out. His position as the head of a leading firm of bookbinders enabled him to give frequent help to the Editor and others on matters connected with the book-trade, and this practical experience was of great value to the Association. He contributed papers to the PROCEEDINGS dealing with the Lower Greensand of Surrey and of the Isle of Wight and on sections at Dulwich, and he conducted several excursions in Surrey, and also one to the Tertiary area of the Isle of Wight.

In G. J. Smith and J. Wadeson the Association loses two of its oldest members, the former having been elected in 1859 and the latter in 1862.

The finances of the Association continue to be in a satisfactory condition. The income in 1906 was slightly larger than in 1905. An increase was shown in admission fees, in annual subscriptions, and in the proceeds from the sale of publications. On the other hand, there was a drop of £10 in life composition fees. During the year £50 was invested, which brings the total invested capital of the Association to £1,217 2s. 6d. Nottingham Corporation Stock, which is worth at current prices about £1,095, and is equal to a sum of nearly £6 10s. in respect of each living compounder. The ordinary expenditure for the year 1906 amounted to £243 2s. 5d., as compared with £224 14s. 3d. for 1905.

The PROCEEDINGS of the year have been issued in 4 numbers, which practically complete the nineteenth volume. They comprise 233 pages of text, 6 plates, and 31 figures. The thanks of the Association are due to the several authors for their communications, and also to Dr. A. Smith Woodward, F.R.S., for the loan of blocks and preparation of drawings, to the Director of the Geological Survey for allowing the Geological Map of the Lummaton and Barton District to be adapted from the Survey Map, to W. P. Young, Esq., F.R.M.S., and H. W. Monckton, Esq., F.L.S., F.G.S., for photographs taken at Lyme Regis, and to Godfrey Bingley, Esq., for photographs lent to illustrate the report of the Yorkshire Excursion.

GEOLOGISTS' ASSOCIATION.

Dr. Income and Expenditure for the Year ending Dec. 31st, 1906. Cr.

	£	s.	d.
To Balance from 1905	134	19	1
„ Life Compositions	22	10	0
„ Admission Fees	22	10	0
„ Annual Subscriptions	198	19	6
„ Dividends on Nottingham Corporation Stock ...	33	1	10
„ Sale of Publications	14	7	11
	£426	8	4

	£	s.	d.
By Printing "Proceedings"	119	1	0
„ „ Monthly Circulars	22	18	6
„ Miscellaneous Printing	13	6	0
„ Illustrating "Proceedings" and Circulars ...	10	5	4
„ Postage, Telegrams and Messages	36	10	11½
„ Addressing	7	13	4
„ Library	2	18	8
„ Attendance, Lighting, Lantern, etc., at Evening Meetings	15	11	0
„ Excursions	5	14	4
„ Insurance	2	15	0
„ Stationery	4	13	3
„ Miscellaneous Expenses	1	15	0½
„ Purchase of £56 0s. 10d. Nottingham Corporation Stock	50	0	0
„ Balance at Bank of England, Dec. 31st, 1906 ...	133	5	11
	£426	8	4

We have compared the above account with the vouchers, and find it correct.
We have also verified the investment of £1,217 2s. 6d. Nottingham Corporation Stock.

January 17th, 1907.

HENRY KIDNER, } *Auditors.*
J. VINCENT ELSDEN, }

The additions to the library for the year include, beside the usual serial publications received in exchange, several reprints of papers presented by the authors, together with the volumes of the British Museum Catalogue, and the Geological Survey Memoirs, published during the year, and thanks are due to the various donors.

An expenditure of about £7 has been incurred on binding, but there are still many arrears. The proposal to hand over the Library to University College alluded to in last year's Report was considered at a Special General Meeting on July 6th, and carried by a large majority. In accordance with this resolution the Library has been offered to University College and accepted by them on the terms proposed by the Association, and a deed legalising the transfer is in course of preparation.

The following is a list of the papers read at the evening meetings.

"The Study of Fossil Fishes" (Presidential Address), by A. SMITH WOODWARD, LL.D., F.R.S., F.L.S., F.G.S.

"Remarks on the Upper Chalk of Surrey," by A. J. JUKES-BROWNE. B.A., F.G.S.

"The Devonian Limestones of Lummaton Hill, near Torquay," by A. J. JUKES-BROWNE, B.A., F.G.S.

"Note on an Ostracodal Limestone from Durlston Bay, Dorset," by FREDERICK CHAPMAN, A.L.S., F.R.M.S.

"The Felsitic Agglomerate of the Charnwood Forest," by F. W. BENNETT, M.D., B.Sc.

"On the occurence of Quartzose Gravel in the Reading Beds at Lane End, Bucks" by H. J. OSBORNE-WHITE, F.G.S.

"On the Higher Zones of the Upper Chalk in the Western Part of the London Basin," by LL. TREACHER, F.G.S., and H. J. OSBORNE-WHITE, F.G.S.

"The Geology of the Yorkshire Coast between Redcar and Robin Hood's Bay," by the President, R. S. HERRIES, M.A., V.P.G.S.

"The Rhætic and contiguous Deposits of Devon and Dorset," by L. RICHARDSON, F.G.S.

"The Zones of the White Chalk of the English Coast, Part V., the Isle of Wight," by DR. ARTHUR W. ROWE, F.G.S.

Lectures were delivered by HORACE W. MONCKTON, V.P.L.S., F.G.S. "On the Geology of the country around the Sogne Fjord and the Hardanger Fjord, Norway;" by S. HAZZLEDINE WARREN, F.G.S., on "The Pressure-chipping of Flint, and the question of Eolithic Man" (with a practical demonstration of the process), and by G. W. LAMPLUGH, F.R.S., F.G.S., on "The Erosion of the Batoka Gorge of the Zambesi."

The thanks of the Association are due to all these gentlemen.

During the year twenty excursions have been made, comprising three Museum visits, eight half-day and six whole-day excursions, besides the three longer excursions, at Easter, Whitsun, and the end of July.

The following is a list of the dates, localities, and directors:

DATE.	PLACE.	DIRECTORS.
March 10	British Museum (Nat. Hist.)	Dr. A. Smith Woodward, F.R.S., F.G.S.
March 17	Essex Museum of Natural History.	W. Cole, F.L.S., F.E.S.
March 24	Mr. Dibley's Collection	G. E. Dibley, F.G.S.
March 31	Whetstone and N. Finchley	Griffith Humphreys.
April 7	Ingatestone, etc.	A. E. Salter, D.Sc., F.G.S.
April 13 to 17 (Easter)	Lyme Regis	Horace B. Woodward, F.R.S., F.G.S., and G. W. Young, F.G.S.
April 28	East Wickham	A. L. Leach, and B. C. Polkinghorne, B.Sc.
May 5	Ashstead and Headley	G. W. Young, F.G.S.
May 12	Boxford and Winterbourne	H. J. Osborne-White, F.G.S., and Ll. Treacher, F.G.S.
May 19	Battle and Netherfield	W. Whitaker, B.A. F.R.S., F.G.S., and E. J. Baily
May 26	Ayot Green and Hatfield	H. W. Monckton, F.L.S., F.G.S., and J. Hopkinson, F.L.S., F.G.S.
June 2 to 6 (Whitsun)	Isle of Wight	The President, G. W. Colenutt, F.G.S., and R. W. Hooley, F.G.S.
June 16	Stamford, Ketton, and Collyweston	Beeby Thompson, F.G.S., F.C.S.
June 23	Lewes	G. E. Dibley, F.G.S.
June 30	Shere and Albury	The President.
July 7	Danbury and Little Baddow (by invitation of the Essex Field Club.)	A. E. Briscoe, B.Sc. Miller Christy, F.L.S. W. Cole. F.L.S., F.E.S. T. W. Reader, F.G.S., and A. E. Salter, D.Sc., F.G.S.
July 14	Bentley, Suffolk	E. P. Ridley, F.G.S.
July 21	Ightham	F. J. Bennett, F.G.S., and B. Harrison.
July 23 to 31 (Long Excursion)	Yorkshire Coast (Whitby District)	The President.
September 15	Rayleigh Hills	A. E. Salter, D.Sc., F.G.S.

Detailed reports of these excursions will be found in the PROCEEDINGS.

No special Cycling Excursions have been arranged during the past year, they not having been well attended in former seasons.

The difficulty in getting attractive half-day excursions has led to an increase in the number of whole day excursions, and this course has been justified by results, a very early start alone being unpopular.

The attendance at the Easter Excursion was a record one, and that at the Whitby Excursion was smaller than would have been the case had it not been held rather earlier than usual to suit the exigencies of the tide, but this did not detract from the great interest of the excursion.

The cost to the Association in the past year owing to guarantee of reduced fares was £1 17s. 9d.

The Excursion Committee think it desirable in future that more copies of the Long Excursion Pamphlet should be printed and a certain number left on sale with the principal bookseller in the town where the excursion is held. This course was adopted last year at Whitby and proved very successful financially, and will, they think, tend to increase the membership of the Association.

The Committee suggest that it would add to the interest of the longer excursions if one or two of the members attending made a special effort to get together a representative collection of specimens and photographs illustrating the excursion for exhibition at the November soirée.

The Excursion Secretaries responsible for the organization of the excursions have been Messrs G. E. Dibley, H. Kidner, T. W. Reader, W. P. D. Stebbing, A. H. Williams, G. W. Young and A. C. Young.

Thanks are due to the Directors of the Excursions and also to the following for assistance and hospitality: Mrs. Dibley at Sydenham, Mr. and Mrs. Allhusen, and Sir Wilfrid Peek, Bart., at Lyme Regis, Mr. J. Dewhirst at Ingatestone and Great Baddow, Mr. H. W. Kemp at Netherfield, Mrs. Colenut at Ryde, Miss Spottiswoode at Shere, The Essex Field Club and Mrs. Briscoe at Danbury, Mrs. Booth and Messrs. Boswell and Batchelder at Bentley, Rev. Canon Austin and Messrs. T. Newbitt and W. H. Hamilton at Whitby, and also to the Director of the Geological Survey for the one-inch Geological Maps published during the year.

The following are the changes in the house list:

Mr. H. W. Monckton retires from the Vice-Presidency; Dr. A. E. Salter finds himself compelled to resign the Editorship; and Dr. J. S. Flett, Miss M. Healey, Dr. F. L. Kitchin, and Miss E. Pearse, retire from the Council.

Thanks are due to all of these for the assistance they have rendered in carrying on the business of the Association and especially to Dr. Salter for the excellent way in which he carried out the duties of Editor.

It was moved by Mr. Griffith Humphreys, seconded by Mr. J. Barrow and resolved, "That the Report just read be adopted as the Annual Report of the Association for the year 1906, including the statement of account."

The scrutineers reported that the following had been duly elected as Officers and Council for the ensuing year:

PRESIDENT:

R. S. Herries, M.A., V.P.G S.

VICE-PRESIDENTS:

Upfield Green, F.G.S.
E. T. Newton, F.R.S., F.G.S.
Capt. A. W. Stiffe, F.G.S.
A. Smith Woodward, LL.D. F.R.S., F.L.S., F.G.S.

TREASURER:

R. Holland.

SECRETARIES:

G. W. Young, F.G.S.
A. C. Young, F.C.S.

EDITOR:

H. W. Monckton, V.P.L.S., F.G.S., F.R.N.S.

LIBRARIAN:

Prof. E. J. Garwood, M.A., F.G.S.

TWELVE OTHER MEMBERS OF COUNCIL:

H. A. Allen, F.G.S.
C. W. Andrews, D.Sc., F.R.S., F.G.S.
G. E. Dibley, F.G.S.
T. V. Holmes, F.G.S.
Miss M. S. Johnston.
H. Kidner, F.G.S.
T. W. Reader, F.G.S.
A. E. Salter, D.Sc., F.G.S.
W. P. D. Stebbing, F.G.S.
Ll. Treacher, F.G.S.
Prof. W. W. Watts, M.A., M.Sc., F.R.S., F.G.S.
W. Whitaker, B.A., F.R.S., F.G.S.,

The best thanks of the Association were voted to the retiring Officers, and Members of Council, and also to the Auditors and Scrutineers.

The President then delivered his Address, entitled, "The Constitution and Management of Scientific Societies."

On the motion of Mr. W. Whitaker, F.R.S., seconded by Dr. A. Smith Woodward, F.R.S., it was resolved: "That the President's Address just read be printed in extenso."

This terminated the Annual Meeting.

ORDINARY MEETING.

FRIDAY, FEBRUARY 1ST, 1907.

R. S. HERRIES, M.A., V.P.G.S., President, in the Chair.

The following were elected members of the Association: Walter Johnson, F.G.S., Frank Pickford, M.A., William H. Seabrook, Miss Caroline E. Shuckburgh, Miss Mary C. Sturgeon, J. W. Vaughan.

There being no further business the meeting terminated.

THE CONSTITUTION AND MANAGEMENT OF SCIENTIFIC SOCIETIES.

By R. S. HERRIES. M A., V.P.G.S.

(Presidential Address delivered February 1st, 1907.)

IT is not the custom with us, as in some societies, for the President to embody in his annual address obituary notices of the members we have lost by death. These losses are mentioned, instead, in the Annual Report of the Council, and short accounts are given of those who have been most prominent. But before entering upon the subject of my address this evening, and without wishing to create any precedent, I cannot refrain from noticing the exceptional losses we have sustained during the past year, including as they do our Secretary, one of our Vice-Presidents who had served his term in this chair, a former Excursion Secretary, one of the authors of the excellent work on the Paris Basin published by the Association, and several other old friends. They are all named in the Report you have heard read, but I should like also to remind you of the death of one who, though not one of our members, was well-known to most of us as a leader of our excursions and contributor to our PROCEEDINGS. I refer to Mr. J. G. Goodchild, whose death took place on February 21st last year, soon after our Annual Meeting. He acted as Director of the Long Excursion on three occasions, viz., in 1889 to West Cumberland, in 1897 on the Edinburgh Excursion, and in 1903 to Berwick-on-Tweed. He had a genius for conducting excursions, and though his views were sometimes heretical he was a very able geologist, and a good friend of the Association.

It is customary on the death of an ex-President, or any other member who has rendered signal service to the Association, for the President to make some reference to the occurrence on the first opportunity. Such references I made at our meetings in June and December, on the occasions of the deaths of Mr. Emary and Mr. Thomas Leighton, but it so happened that Professor Blake's death took place on July 7th, the day after our last meeting of the session. No opportunity, therefore, arose to refer to it till November, and as that was the conversazione I thought it better to reserve what I had to say until the Annual Meeting, though I was able to discharge my own personal obligation to him in a note to the paper I prepared for the Yorkshire Coast Excursion. You have already heard the details of Professsor Blake's life and connection with this Association in the Report, and the titles of his principal papers are there given. Undoubtedly his chief claim to the title of a distinguished geologist rests on the work he did among the Jurassic Rocks. His monographs on the Kimeridge Clay, the Portland Rocks, the Corallian Rocks (with Mr. Hudleston), and the Yorkshire Lias (with the late Professor Tate), are monuments of accuracy and research. Though he afterwards travelled into other fields it was always to the Jurassic or Cretaceous that he loved to return, and his first paper that I have a note of was published in 1870 in the Proceedings of the Yorkshire Naturalists' Club, on the Red Chalk, while his last work was the monograph begun in 1905 for the Palæontographical Society on the Cornbrash, which he did not live to finish. During all that time there are only two years, 1895 and 1896 (when he was in India), in which I do not find that something from his pen was published, from which may be gathered the voluminous character of his writings. He had an eminently critical mind, and was never content to take things for granted, whether it was the orthodox view, or some heterodoxy which was attracting geologists. There was no subject too difficult for him, and during the last twenty-five years there was hardly a controversy into which he did not plunge with his characteristic energy. It is enough to mention the rocks of St. David's, the North West Highlands, Anglesey and Carnarvonshire, the Shropshire Cambrians and Pre-Cambrians among the older rocks, and the Isle of Wight Oligocene controversy raised by Professor Judd, and the Moel Tryfaen shell bed among the later deposits. We must remember, too, that he brought out four volumes of the Annals of British Geology, a work which alone would have taken the whole time of most men. He was also a good palæontologist, and had made a special study of the Cephalopoda, some of the results of which he laid before this Association in the two able presidential addresses which he delivered here. Perhaps the work by which he hoped to go down to fame was that which he did on the Anglesey rocks, to which he gave the name of Monian, but his views on this and on the Carvarnonshire area did not meet with general acceptance among other workers in the same field, and possibly it is still too soon to judge his work there, which may perhaps, as has so often happened, be more highly thought of by those that come after than by his contemporaries. Still, be that as it may, the work he did amongst the Secondary Rocks, and his contributions to palæontology, will entitle him to a high place among the eminent geologists of his time.

Blake had a great regard for the Association, and was a *persona grata* to its members. He was President, he edited the PROCEEDINGS, he was several times Vice-President and hardly ever off the Council. I find that including reports of excursions at least twenty-three of his papers were published in our PROCEEDINGS, two being Presidential Addresses. As a director of excursions he was indefatigable. When President he conducted five out of the six Long Excursions during his two years of office. We all remember his short, quick step, and the marvellous rapidity with which he got over the ground, and the almost boyish enthusiasm with which he threw himself into the work of fossil collecting in the quarry or on the shore. It was with sorrow that we noted the change coming over him during the last year of his life, particularly at the Llandrindod Wells Excursion, and when the end came, rather suddenly at the last, we realised that the Association had lost one of its truest friends.

By a long-standing custom there is imposed on anyone who accepts the office of President of a Scientific Society the task of at least once a year addressing those who have conferred that high honour upon him. Sometimes this duty is performed as an inaugural address at the beginning of the term of office, but in other cases, as in our Association, the burden hangs round the neck of the President like a millstone throughout the whole year. If he tries to forget it some officious friend is sure to remind him of it by trying to find out what he is going to talk about. I say talk, because when a short time ago our Editor mentioned to me that he had no copy in hand for the February number of the PROCEEDINGS, and suggested that it would be convenient if he could send my address to the printers at once, I was obliged to confess that I had not written a word. I then felt somewhat in the position of those secretaries of slate-clubs, of whom we have heard, who, when the time comes for sharing out, do not feel inclined to meet their fellow-members, and I was much tempted, as the Annual Meeting came nearer and nearer, to play the part of the missing President, in which case I am sure that one of your able Vice-Presidents would have risen to the occasion and delivered a most excellent address on the spur of the moment.

But I remembered that though this hard task was laid on the President no limitations were placed on his choice of a subject, and that, whatever he might choose to talk about, you would as in duty bound listen to him. I also reflected that the Association audience was very indulgent, and that it was even possible that our excellent Secretary before hearing a word of the address would have found a proposer and seconder for a motion that it be printed in the PROCEEDINGS. I therefore plucked up heart and determined to go through the ordeal.

The subject I have chosen, namely, "The Constitution and Management of Scientific Societies," though not strictly geological, has at any rate an important bearing on the Science; and as I have been serving on your Council continuously for the last fourteen years and on that of another Society for almost as long, in both cases for a considerable part of the time as an executive officer, it does not seem to me amiss that I should give you some notes on the experience that I have thus gained.

I have divided the subject into two heads, and by Constitution I mean such fundamental things as the name and object of existence of a Society, the different classes of members and the qualifications for membership, the establishment and powers of the governing body, and the right to make and vary rules or bye-laws; by Management I mean such ministerial matters as the general conduct of the Society's affairs, the care of its property, the proceedings at its meetings, the contributions of members, the particular method (within the constitutional limits) of electing both the members and the governing body.

During the last few years there has been much discussion and criticism, public as well as private, under both these heads in many societies. Few, in fact, from the Royal Society downwards, have escaped, though I believe we have been more fortunate than others in that respect. I hope in the following remarks to deal with a few of the points which have been raised from time to time.

It is possible to conceive a society in its simplest form with neither rules nor a governing body. A few students or devotees of a particular science might agree to meet together from time to time at each other's houses in turn, for discussion or the exhibition of specimens, the host for the day acting as chairman of the meeting. There was such a society when I was at Cambridge, and I hope it still flourishes, the Sedgwick Club, composed of undergraduates who were taking up geology. If it had any rules, they were only in manuscript and of the simplest character. To some such assemblage, meeting from time to time, we owe the foundation of the Geological Society, now entering on its hundredth year.

Sooner or later, if a society is a growing one, the question of money is sure to come in, and rules of some sort become a necessity. Either the members will want to publish some of the papers that are read, or as their numbers increase they will find it necessary to hire a room for their meetings, to have a salaried secretary, and perhaps to start a library for the common use of the society. In any such case it will be necessary to impose a subscription on the members, a treasurer will have to be appointed to collect and receive those subscriptions, and probably a committee or council will come into existence, whose duty it will be to see that the money is laid out to the best advantange. As the membership increases and extends beyond the original circle, rules must be framed for regulating the admission of candidates, the times of meetings and so on, and the method of election and powers of the committee or council must be settled.

Our own Association, starting as it did by the calling of a meeting of persons interested in the formation of a society on the lines with which we are all so familiar, many of whom were strangers to each other, had from the first its code of rules and Committee of Management. The Rules may be taken as a type of what short and simple rules may be. I do not pretend that they are perfect, indeed, there is one which is a sore puzzle to those whose duty it is to interpret it, namely, the rule concerning the election of the Council, which I would gladly see revised. That, however, is more or less a matter of drafting, and does not affect the merits of the rules as a whole. As you know, our Rules (see pages 1 to 4) are only twenty-four in number, and are contained in four octavo pages. The first four are constitutional, dealing with the name and objects of the Association: the classes of members and their privileges. Then follow three (5 to 7) dealing with the method of electing members, four (8 to 11) with contributions, and one (No. 12) with the removal of members. The next five (13 to 17) concern the Council and Officers, Committees and Trustees. No. 18 requires minutes to be taken, and the various kinds of meetings are dealt with in the next three (19 to 21). Honorary Members are defined in Rule 22, and the last two (23 and 24) provide for the publication and revision of the Rules, the last being essentially constitutional. The rest, except the first four and to some extent Nos. 13, 17, 20, and 22, come under the head of Management.

I may remark in passing that our Rules have been very little altered since they were originally settled on December 17th, 1858, nearly fifty years ago. Such alterations as there have been are mostly in matters of detail, and it is evident that the original set of Rules must have been drawn up with considerable skill. Such a code, simple as it is, contains all we want, and I hope we may long continue to flourish under it.

Many societies, especially when they grow large, are not content with the "simple life," but proceed to the further step of becoming incorporated. The advantages of such a course are that the society instead of being a mere collection of individuals becomes a legal entity under its corporate name. It can sue and be sued, it can enter into contracts, sealing them with its corporate seal, it can make bye-laws, and what is perhaps most important it can, in spite of the Mortmain Acts, own land within such limitations as are laid down by the instrument of incorporation; besides all this there is a certain added importance and dignity, which in several cases has had a practical recognition at the hands of the Government by the grant of public rooms in which to hold the meetings. On the other hand there are disadvantages, especially in the strict limitations which the charter or other instrument of incorporation places on the scope and freedom of action of the society.

There are, I believe, three methods by which a number of individuals can be incorporated. The first and usual method is by Royal Charter, the second is by a Special Act of Parliament, and the third is by the machinery provided by the Companies

Acts, a well understood process, founded on a series of General Acts of Parliament. The Royal Institution is an instance of a society which has a Special Act, which is, however, supplemental to an earlier charter, and at least one of the great professionaal societies has taken advantage of the powers under the Companies Acts. But by far the largest number of the incorporated societies have obtained Royal Charters.

These charters are all very much alike, and are founded more or less on that of the parent of all English scientific societies, the Royal Society. They begin by reciting the objects for which the society is formed, then follows the act of incorporation under the corporate name of the society and certain privileges which are thereby granted, namely, the power to own personal property, and, within certain limits, real property, to sue and to be sued, and to have a common seal. They then deal with the number and different classes of members, and provide for the government of the society by a president and council, and regulate the method of appointing such governing body, who are made practically absolute. The method of election of the members is then indicated, and power is given to the fellows or members to make, alter, and repeal such bye-laws as they choose, provided they do not contravene the provisions of the charter or the law of the land.

Within these outlines there is some scope for variation, and for provisions suitable to the requirement of particular societies, but it must be remembered that the charter when granted is binding once for all, and that whatever is done must be within the four corners of this sacred document, there being no relief except in obtaining a further charter supplementary to the original one. For this reason it behoves those entrusted with the drafting of a charter to proceed with the utmost care, and to have clearly in their minds not only exactly what the requirements of the society at present are, but to foresee what their wants may be in the future; for a too strictly drawn charter may very easily have the effect of limiting the expansion and consequent usefulness of the society bound by it. As an instance of how the working of a charter may defeat the intentions of its framers, I may mention that soon after the incorporation of the Geological Society it was proposed to make a bye-law, in accordance with a rule that had previously existed, limiting the term of consecutive service in the office of president to two years. Doubts were raised, and the opinion of the then Solicitor-General was taken, and he advised that such a bye-law would be invalid, as the charter gave absolute freedom of choice to the fellows to elect annually as president whom they would from among those chosen for the council, so that if a fellow who had served two years in that office was again on the council, no bye-law could be made to prevent him from being elected president for a third time without infringing the rights of the fellows as given them in the charter. Here was a case where everybody knew what they wanted, but they had tied their hands and could no longer give their intentions legal force, but the feeling that was then manifested has left its mark, and the unwritten custom, strong as law, has prevailed unbroken for more than eighty years from that time.

Some recent charters are much more simple. As an instance I may mention that of the Entomological Society, founded in 1833, but not incorporated till 1885. It merely decrees that the thirteen persons then forming the council should form the first council of the corporation, and that the existing bye-laws should be the bye-laws of the corporation, with power to make new ones or alter or revoke them as may be necessary. It will be understood that such a charter as this, which practically allows everything to be settled by bye-laws, leaves the society almost as free as it was before being incorporated.

As soon as a society is incorporated it proceeds to frame bye-laws. If it is not a new society, these probably follow the lines of its previous code of rules, being however much amplified to suit the dignity of the occasion, so that the bye-laws of an average chartered society fill the pages of a moderate-sized pamphlet instead of the modest four pages with which we are content. These bye-laws are generally divided into sections, each of which deals with a separate subject, such as the admission of fellows; their withdrawal or removal; their contributions; their privileges; different classes (if any), such as honorary members, associates, and the like; the duties, powers, and method of election of the council and officers; the method of altering the bye-laws; the various kinds of meetings to be held; and the reading and publication of papers.

All these details vary very much according to the requirements or objects of the different societies concerned. For instance while in such societies as the Linnean and Geological candidates are elected by ballot on the certificate of certain fellows that they have the requisite qualification, in most of the great professional societies admission can only be obtained by proof of qualification through examination, or the production of a thesis.

I have pointed out that the older incorporated societies are somewhat restricted by their charters, but it must not therefore be supposed that unchartered societies are absolutely free to do as they please, and defy all law, like the trades unions under the new Act. They are in fact governed by the Literary and Scientific Institutions Act of 1854, of the existence of which possibly not many of you are aware. This Act recites that "it is expedient that greater facilities should be afforded for procuring and settling sites and buildings in trust for institutions established for the promotion of literature, science, or the fine arts, or for the diffusion of useful knowledge, and that other provision should be made for improving the legal condition of such institutions." After enacting that gifts or sales of land may be made to the extent of not more than one acre as sites for literary or scientific institutions it proceeds to lay down rules for the general government of such institutions. Among other things it provides (i) that in societies that are not incorporated, and have no trustees, the personal property shall vest in the governing body, who may be described as the owners in all legal proceedings; (ii) that societies not incorporated "may sue or be sued in the name of the president, chairman, principal secretary, or clerk, as shall be determined by the rules of the institution, and in default of such determination in the name of such person as shall be appointed by the governing body for the occasion:" (iii) that the governing body may at a meeting specially convened make any bye-law for the better governance of the institution, its members, or officers, and may impose a reasonable pecuniary penalty for the breach thereof, provided that no penalty shall be recoverable unless the bye-law shall have been confirmed by the votes of three-fifths of the members present at a meeting specially convened for the purpose; (iv) that members in arrear of their subscriptions or who detain, injure, or destroy the property of the society may be sued; (v) that in societies not having a royal charter, if it appears to the governing body advisable to alter, extend, or abridge the purpose for which the society was established or to amalgamate with some other institution, the governing body may submit a report to their members, and not less than ten days after may hold a special meeting to consider it. To enable this to be carried into effect the proposition must be agreed to by the votes of three-fifths of the members present, and it must be confirmed by a second special meeting by the same majority. There is a further provision for an appeal to the Board of Trade against this decision on behalf of at least two-fifths of the members; (vi) that any society may be dissolved on the determination of not less than three-fifths of the members, but that on a dissolution the surplus property shall not be distributed among the members, but shall be given to some other institution. A member is defined as "a person who having been admitted according to the rules and regulations shall have paid a subscription or shall have signed the roll or list of members, but in all proceedings under this Act no person shall be entitled to vote or be counted as a member whose current subscription shall be in arrear at the time." The governing body is defined as the "Council, directors, committee, or other body to whom by Act of Parliament, charter, or the rules and regulations of the institution, the management of its affairs is entrusted, and if no such body shall have been constituted on the establishment of the institution, it shall be competent for the members to create for itself a governing body to act for the institution thenceforth." The Act has a general application to all institutions established for the promotion of science, literature, the fine arts, for adult instruction, for the diffusion of useful knowledge, and for the foundation or maintenance of libraries, museums, picture-galleries, and collections, except to the Royal Institution or the London Institution. This Act gives us, without any charter, almost more than we want, and with its somewhat cumbersome provisions it is no wonder that, except as regards the sections dealing with the holding of land, it has become practically a dead letter. If it were strictly regarded, supposing we wished to add, say botany to our objects, we should have to make a report to that effect, have two special meetings to carry it, and even then be subject to an appeal to the Board of Trade. Contrast with that the provision for winding up. Suppose a society to consist of five hundred members. If three hundred of them decide to disband, the society is disbanded. There is no mention of a meeting to be called, or notice to be given to the other two hundred, and they apparently have no right of appeal. There is however a sensible provision, and one generally included in charters of societies, that the property shall not be divided among the members, any surplus must be given to some other society, and a few years ago we had a practical illustration of this, for when the "Amateur Scientific Society" was dissolved they very kindly handed over to this Association their balance in hand, which if I remember right amounted to between three and four pounds.

Having dealt sufficiently with the construction of these societies I will now proceed to consider some of the questions relating to their constitution which as I have already said have been under discussion during the last few years, and some of the criticisms which have been levelled at their management. The principal points are the method of electing the council or whatever other body manages the affairs of the society, the way in which when elected that body does its work, the restrictions placed on the general body of members, the method of voting on questions concerning the society, the manner in which papers communicated to the society are selected for publication, the rights of different classes of members, and the admissibility of women.

Let us first discuss the council in its various phases. As I have already said, it is necessary that a society which has grown to a certain size should have a governing body, unless it is to have a general meeting every time a gas bill has to be paid or an order for printing given, and it is also expedient that, within such limits as may be laid down, the governing body, which we will call the council, should have a free hand, accounting from time to time to the general body of fellows or members who appointed it.

It is usual in all societies that the council should give an account of their stewardship at least once a year, just as is the case with boards of directors of trading companies. On such an occasion, generally called the annual meeting, the council make a report (as our Council have just done), and the individuals composing it are re-elected or are replaced by others as the case may be. A wise provision usually adopted, and universally so, I believe, in chartered societies, is that a certain proportion of the council should retire at the end of each year. It is a curious fact that in our own Association there was no such provision until the last revision of the rules in 1893, when the present rule was put in that there should be at least four members on the new council who had not served during the past year. Before that time it was quite possible for a member to remain on indefinitely if as soon as he became one of the senior unofficial members he was made a vice-president, and when he had got to the top of that list he again joined the unofficial ranks. It has always seemed to me a great proof of the confidence reposed in our Council that this rule went so long unchallenged and unreformed.

Having decided that a certain proportion of the council shall retire, two questions arise, namely, who shall they be?, and who shall replace them? The first may be, and in some cases is, settled automatically by the rules. For instance, it may be a rigid rule that, say, the senior five members retire. This may work in a very inconvenient way, for one of the five might be the most fitting man to be president, or he might be holding the position of treasurer at a critical financial time. It can be arranged that officers do not rank for seniority unless they are retiring, but on the whole it seems best to leave the matter open and it will generally settle itself, subject to such regulations as the council may make for its own guidance. The usual plan, in default of a fixed rule, is to take off part for seniority and part for irregularity in attendance at meetings. The other question—who shall replace those who are taken off?—is a more difficult one, as it cannot be settled by any rules. The custom of most societies is for the council to recommend to the members both who shall go off and who shall be elected in their place. It is expedient that this should be done, or there would be a danger of chaos on the election day. The members would have nothing to guide them. If there were rules as to seniority they would not know who were the seniors, and if everyone had to write out his own voting list he would probably forget that he had to put on so many new members, and it is quite possible that no valid election would be arrived at. The system of recommendation by the council, therefore, is almost a necessity, and in most chartered societies is prescribed in the bye-laws. Though nothing is said about it in our rules it is worth noting that our Council have from the very first adopted that system, and for many years made their recommendation part of the Annual Report. The list proposed by the council is with very rare exceptions adopted by the members. This fact lays the various councils open to the charge, so often made, that they are self-elected bodies, which is in a manner true, but only so long as no grave and general dissatisfaction exists with the council or any individual member of it. In such a case it must be possible for the members to combine and purge the council of the obnoxious members, so far as the rules allow, and replace them by carefully-chosen successors who are pledged to a sound policy. If the members cannot do this when there is real occasion for it it is clear that they would be incapable of acting in ordinary cases without the guidance of the council, as I have pointed out above. If the dissatisfaction is not sufficiently general the opposition to the council will not be so easily successful, as there is always a strong innate conservative feeling partly against a change and consequent ill-feeling, and partly in favour of constituted authority. It is just the same with other bodies, such as social clubs or trading companies; there requires to be a very great deal of dissatisfaction before extreme steps are taken, but that boards are not infrequently upset, especially in the more speculative class of companies, must be well-known, and it has even happened during the last few years to one of our leading Railway Companies and one of our best-known lines of steamers. It must be remembered that in the case of companies the voting is not by individuals but by shares, so that the difficulty of successful combination is greater, as the members of the board have usually a considerable number of shares amongst them.

In a system of election such as is prescribed by our own rules, where the whole council is thrown into the melting pot, the chances of a successful opposition to an individual member of the council, or of bringing in a member not recommended by the council, is somewhat remote. The late Professor Blake pointed this out in a pamphlet he issued to the Fellows of the Geological Society, where the method is very similar to our own. In this pamphlet, entitled "The Geological Society of London: Suggestions for Certain Improvements, 1901," he points out that "a majority of voters cannot be sure of removing a member of council unless they agree also as to the person who is to take his place, nor of electing a new member unless they agree also as to the person whose place he is to take." The remedy he proposes is to pass a bye-law limiting the number of fellows to be removed annually to five (the minimum under the charter). Such a bye-law would however in that Society be invalid as limiting the powers of the fellows given them by the charter, namely to "remove one fifth *or more*," just as in the case which I have mentioned above regarding the proposed limitation of the Presidential period of service. Here therefore at first sight the privileges reserved to fellows in the charter seem to operate to their disadvantage, but on the other hand it is quite competent to the fellows to remove the whole council and replace them by others, when the difficulty raised by Professor Blake would not arise, as all the dissentients would have to do would be to strike out the whole recommended list, and write down another previously agreed on. This could not be done in such a society as the Zoological, as to which Professor Blake mistakenly says that it is founded on a charter similarly worded to that of the Geological Society, whereas their charter lays down the precise number to be removed as five. Nor could such a *coup d'état* take place in the Linnean Society, where their latest charter prescribes that one fourth *and no more* shall be removed.

We know at any rate that under the ordinary conditions it is quite possible for a section of the members working together to cause the rejection of the council's nominee to some office in favour of their own candidate. The circumstances of the election of the present able Secretary of the Zoological Society will be fresh in most of your memories. That was a case in which a charter and bye-laws, of quite ordinary type, presented no bar to the successful running of an opposition candidate. You will remember that a somewhat similar contest took place last year at another society well known to all of us. In that case however the opposition were not strong enough to defeat the council.

It is quite true, however, as I have already pointed out, that the strength of the council, when opposed, lies in the solidity of its nomination list. It cannot be defeated by casual opposition, but only by organised combination, for which there is not usually very much time. Two remedies have been suggested and frequently urged; one is a system of counter-nomination by private members, and the other is voting by proxy, which latter is, of course, equally applicable to voting at special meetings. The question whether either or both of these systems can be adopted depends on the charter (if any) and the bye-laws. So far as I can see there is nothing in our own rules against nomination of any candidates other than those nominated by the council. Indeed, the rule is singularly silent as to the method of election, all it provides being that the election be by ballot, and that it take place at the Annual Meeting. As I have already said there is no provision even for the council nominating, but they have always assumed the power, and probably anyone else could do the same. I doubt whether proxy voting would be valid without a special rule being passed, and it certainly would not be permissible at a Special General Meeting for altering the rules, as it is laid down that "No rule shall be altered except by a majority of votes of those *present* at a Special General Meeting." Nothing is gained by having nominations which may be handed in at any time up to the opening of the ballot. The object of nomination is to let the members know who are being proposed, and, therefore, if the system is to be of any use at all the nominations must be received not less than say ten days or a week before the day of ballot. After that no further nominations would be received, and at the meeting votes could only be cast for those who had been nominated. Such a system, however desirable, is not permissible under the usual form of charter of the incorporated Societies, for there is no power to limit the choice of members when voting at the Annual Meeting to this or that set of candidates. They are quite at liberty to vote for any member they please, and if such a person gets a majority of votes he is elected whether he was nominated or not. The same difficulty arises with regard to proxy votes, because the charter generally directs that the fellows shall assemble in a certain place and then and there proceed to elect. This seems to require the actual presence of the voters, and precludes the idea of proxy voting. It is, however, quite feasible to frame a charter on lines that will make the nomination system or voting by proxy or both perfectly valid. For instance, the Institution of Civil Engineers not long ago obtained a supplementary charter which permitted voting by proxy, and there are other societies with a widespread membership which have adopted the same course:

One society, I notice, gives by a bye-law a proxy vote to its lady-fellows, and as they are said to enjoy all the privileges of fellows this is, presumably, an additional privilege, and as it seems to be contrary to their charter any votes given under it, if challenged, would probably be held to be invalid.

I have shown how these two often quoted remedies of nomination and proxy voting can be adopted, and I will now consider the question of expediency. As regards nomination, I think it is the best system that can be devised. Everything must be fair and aboveboard, and there can be no question of surprises. It is the only way to my mind in which the rights of the independent fellow to exercise a choice can be secured. As regards proxy voting, on the other hand, I think it would work out in favour of the governing body. As I have already said, there is always a large inert body of people ready to support those in authority, but they will not always take the trouble to come from a distance to register their votes. They say, "Oh! the council are sure to win, so my vote won't make any difference, and I needn't trouble to go up to London and vote." It is just these people who would benefit by the adoption of the proxy system. On the other hand the dissatisfied element are much more actively minded—the mere fact that they take the trouble to be dissatisfied proves it, and they will marshal their forces and bring up every available man. They are not likely to gain by the introduction of the proxy vote. This is seen constantly at the meetings of trading companies, when an adverse vote is often at first carried against the board, whereupon the chairman has recourse to his proxies and wins an easy victory. It is moreover always possible to informally poll the society on any particular question. The late Professor Blake did this in respect of the Geological Society when he issued the pamphlet which I have mentioned. He took the opinion of the fellows on a variety of subjects, and when his results were laid before the council they received every attention from that body.

I think I have now shown that the present common system of nomination by the council and voting by ballot at the meeting is not so open to objection as its critics would have us believe, though I think that, when the charter or rules allow it, a system of nomination by the council or others in advance is fairer to all parties; but before I leave the subject I should like to say a word as to how the councils do their duties. Personally I have only had experience of two such bodies, but that experience has been a long one, and I have had many friends who have served on the Councils of other societies. The conclusion I have come to is that these bodies and the individuals who compose them have a sincere desire to do their best for their society, and that in this particular instance of the nomination of their successors they do give very careful consideration to the problem. I have already indicated that the usual method of selecting those who are to retire is by considering seniority of service and irregularity of attendance. The decision as to new nominations is usually by ballot, and regard is had to the character of those going off, so as to keep up a fair balance of representatives of all parties, such as professionals and amateurs, or town and country members. The question of bringing on new blood is also considered, the Geological Society Council, for instance, having a standing order that at least two of the five to be nominated shall be entirely new to the council. The same society has also during the last few years issued notices inviting suggestions for membership of the new council. The names sent in are carefully considered by the council in coming to a decision, and this method gives ample opportunities for the claims of any fellow to be brought forward which might otherwise be overlooked. Unfortunately, very few fellows respond to the invitation, which, perhaps, shows that they are in the main contented with the council's selection.

With regard to the choice of officers the practice varies. In some societies the president nominates, probably after consultation with others, and the council accepts his nomination without question. In our Association there used to be a prevailing notion that each officer was supposed to find his own successor when he retired. Such an idea is to my mind a preposterous one. It lays a heavy burden on anyone taking office, and it binds the council to take his nominee, who may not be at all fitted for the post, but has been suggested by the retiring officer in desperation, as it were, to get rid of his responsibility. The system which has been adopted lately has been to appoint a small committee to draw up a list of suitable candidates and to offer the post to them in such order as the committee think best. This seems to work so well that I hope it may be continued. The President, it is true, continues to nominate his successor in office but only after taking the advice of those who are in his opinion best qualified to give it.

The management of a society by its council is, as we have seen, an absolute one, but the fellows or members are not wholly shut out from control. They have the power to frame the original code of rules or bye-laws, and these cannot be altered or repealed without their sanction. No doubt, as a rule, suggested alterations of bye-laws originate with the council, but unless the code when first framed had contained reasonable provisions for safeguarding the interests of private members, it would have had little chance of being passed. As it is, new bye-laws can be, and sometimes are proposed by private members and there are not the same difficulties in their way in voting at a special general meeting as there are at the election of the council. Amongst other things, the bye-laws generally provide for the holding of special general meetings on the requisition of the council, or some specified number of private members, and at such meetings any matter can be discussed by way of resolution or otherwise of which due notice has been given.

Thus there is an absolute right reserved to the private member of ventilating grievances, of criticising the action of the council, or of formulating a new constructive policy; and there is the co-ordinate right of opposing any resolution brought forward by the council. That such a resolution can be successfully opposed, many of us who are fellows of the Geological Society will remember. I refer to the occasion when the Council recommended that the Society's museum be transferred to the Trustees of the British Museum. They had gone so far as to approach the Trustees on the subject, and all the arrangements had practically been made. A very strong feeling, however, was expressed at the meeting against the proposal, and eventually after a long discussion the "previous question" was moved and carried by a majority of about three to one.

A further privilege of members is to have presented to them annually a report of the council on the affairs of the society, and the rules generally provide that members may freely comment on the report, and heckle the responsible officers, but as a rule no resolution can be proposed other than that of the adoption of the report, which, of course, in extreme cases may be negatived.

It will thus be seen that in spite of the absolutism of the council, the rights of private members are by no means neglected. They can, at any rate theoretically, control the election of the council and officers; they can make or decline to make new bye-laws; they can bring forward proposals at special meetings, or they can discuss and pass, or decline to pass, any proposals put before them by the council; and they can at the end of the year let the council know exactly what they think of them on the annual report. All this is in addition to their ordinary privileges of attending meetings, proposing and electing new members, using the Library (if any), and receiving the Society's publications.

The question of publications must next be considered, and in that respect I have nothing to say about their form, whether they should be octavo or quarto, illustrated or not, freely distributed or paid for. All these things are matters which must be decided by the circumstances and requirements of the different societies. But there remains a very important question, namely, the method of dealing with the material submitted for publication. Of course a society can, if it chooses and has money enough, publish anything that is sent in for the purpose, but unless some sort of selection is made there is the double danger of its publications being extremely bulky, and of their reputation becoming impaired by the amount of chaff that is found with the grain. I think it must be conceded that there is an inherent right in an editor, or in the committee that controls him, to make some selection of his material. It is impossible to imagine, for instance, the editor of a daily newspaper inserting every letter that reaches him, or the editor of a monthly magazine publishing the articles of every would-be contributor. The question resolves itself into one as to the method of making the selection, and the principles which shall guide those responsible.

Perhaps the best way, if you can find the right man, is to entrust the editor with absolute discretion, laying down certain principles for his guidance. It is not, however, easy to find such a man, or at any rate to find one who is willing to undertake so responsible and invidious a task. The council, therefore, usually undertakes control, but generally delegates its duties to a committee. This system, which seems to work well as a rule, has lately been adopted by the Geological Society in place of the old contrivance of a single referee appointed *ad hoc* by the president. The referee had to report to the council, who ballotted as to whether the paper should be printed or not, but if the referee's report was unfavourable a second opinion was always obtained. The system was not a good one, as the council was too large a body to properly consider the report, and the burden of selecting referees was too hard a one to lay on the president. Moreover, the absolute secrecy which was preserved as to the name of the referee was very apt to set the author speculating, and if his paper was condemned he, as likely as not, pitched on the wrong man, and feelings were thus engendered without any foundation which tended to undermine pre-existing friendly relations. The new system provides for a standing committee, appointed annually by the council, but not confined to the members of the council, and their names are published. Of course on many papers they have to get expert advice, but the selection of the experts is very carefully thought out in committee, and their reports receive much closer attention than was possible when they were read before a full council. The Zoological Society have a still better plan, the publication committee being elected by the fellows at the annual meeting in the same way as the council, three retiring every year.

Our own Association can hardly be said to have any system, but then we are not generally oppressed with a greater mass of material than we can publish, nor do we demand that all communications should represent original work. As a matter of fact the Secretaries and the Editor between them are competent to decide on the value of a paper, and it is only in rare cases, such as of a technical paper by an author whose competence to write on a special subject has yet to be proved, that it is found necessary to call in the aid of a referee.

As to the principles which guide an editor, committee, or referee, as the case may be, these depend on the practice and requirements of the society. Some societies will only publish original work, some will only have practical work as opposed to theoretical speculation, some encourage extreme specialisation, others will have nothing to do with it. The great thing to be aimed at is consistency, so that whatever the guiding principles for the time being are, they should be rigidly adhered to, and no points should be stretched in favour of one author that are not conceded to all. It may be that the question of cost enters in, and the fact that early in the financial year an author has been allowed to be diffuse is sometimes held to be a grievance when towards the end of the same year the treasurer puts his foot down and another author is asked to condense. Such cases, when confined to editorial points and not going to the root of the paper, are not a departure from principle, but are merely due to a want of judgment or miscalculation on the part of those responsible. There is one other point I should mention, and that is the statement which appears on the covers of the publications of many societies to the effect that "authors alone are responsible for the facts and opinions expressed in their papers." It has been represented that in the face of such an expression a committee has no right to make any suggestion to an author as to the modification of any opinion he may have put forward, and that they are bound to publish anything an author sends them, however heretical. This, I need hardly say, is not so, for all the statement is intended to convey is that the reader must not take it that any facts or opinions contained in the publication are vouched for by the publishing society, whose name might otherwise be taken by many as a guarantee that the facts were correct and the opinions orthodox. Any society, though safeguarding itself and warning its readers in this fashion, is quite entitled to further protect the reputation of its published volumes for accuracy and soundness by declining to publish at all or only with certain modifications any papers which are likely to be prejudicial in either of these respects.

As to classes of members, these exist in most of the great professional societies, such as the Civil Engineers and the other Engineering Societies, and in the Medical Colleges. We hear from time to time of complaints as to the respective rights of the various classes, but I have personally had no experience in such matters, and the questions are hardly of such general application as to come within the scope of my address this evening.

I now come to what is perhaps the most delicate part of my subject, namely, the question of the admission or admissibility of women into scientific societies. I speak in the alternative because there are really two questions; one is whether in certain of the chartered societies women are eligible for membership, and the other is whether, even if they are eligible, their admission is desired by the "men in possession." Fortunately we are in a position to look on this controversy without prejudice, because ladies have had their share in our membership from the very first, and their presence at our meetings and excursions has contributed in no small degree to our success as an Association. But not all societies are so fortunate, and for some years many of them have been exercised either as to how they can get them in, or as to how they can keep them out. During the last few years there has undoubtedly been a remarkable change of opinion on this question, and when we find one of our oldest and most important societies, the Linnean, obtaining a new charter mainly for the purpose of legalising the admission of women, we can hardly doubt that another few years will see them freely admitted into every society, subject of course to the same tests by qualification and ballot as men. As to the capacity of women to study and advance our own particular science of geology, it is difficult to see how there can ever have been a doubt, when we remember that one of the early pioneers was no less a person than Mary Anning, who was something more than a mere fossil collector, and recently there has been quite a wave of lady geologists, to particularise whom would be invidious, seeing that many of them are members of our own Association.* The

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* For an account of the geological work of women to that date see the Presidential Address of Mr. H. B. Woodward for 1894, *Proc. Geol. Assoc.*, vol. xiii, p. 263.

Geological Society has several times given to ladies awards from the funds at its disposal, and has accepted and published their papers. A further advance was made when they were admitted as visitors to the meetings, a step which some time before Dr. Henry Woodward had advocated in his Presidential Address to that Society in 1895. As a natural consequence, they were allowed to read their own papers and reply to the discussions raised on them.

With regard to the question of admissibility of women, only the chartered societies are troubled, for the members of other bodies have but to meet and pass a bye-law, and the thing is done. The problem is however much more intricate in the case of corporations in spite of the dictum ot Professor Blake, in the pamphlet I have previously quoted, to the effect that "it is not clear that there is any real question about this" (the admission of women as fellows). He points out that there is nothing in the Geological Society's charter about it, and goes on to say that "it has been supposed that the bye-laws which speak of a candidate as 'him' restrict them to the male sex." I do not know whether anyone seriously held this view; but if they did, I venture to think it quite untenable. If ladies are eligible, either by the charter or bye-laws, the use of the word 'him' would not operate as a bar to their election, nor would the mere addition of the word "her" render them eligible if they were not otherwise admissible. It is true that nearly twenty years ago, when the bye-laws were under revision, an amendment was proposed adding the words "or her" after "him," and was defeated by a narrow majority, but even if it had passed I do not think it would have helped on the question, unless it had been accompanied by a bye-law expressly declaring ladies eligible, and then only if such a course was compatible with the charter. Mr. Monckton has discussed the question from a legal point of view in a short paper entitled "Women as Fellows of Scientific Societies," originally contributed to the *Law Times* in 1893, and afterwards reprinted with other papers for private circulation. This was written about the time that the Royal Geographical Society was in a difficulty owing to doubts having arisen as to the legality of the action of the Council in electing certain ladies as fellows. Mr. Monckton points out that as a general rule women, infants, and aliens cannot be members of a corporation, but this rule has exceptions, and at least no application to the case of trading corporations. He quotes Grant's work "On Corporations" as stating that those that are neither established for gain or municipal purposes, but are strictly voluntary associations, have a right of choosing their members at pleasure, subject to anything in the charter to the contrary. Thus if an existing society admitting women as well as men to membership becomes incorporated, those women members being duly appointed fellows under the charter would it seems be members of the corporation. Mr. Monckton, however, expresses the opinion that if at the time of incorporation no woman was a member, and that for a great many years afterwards no woman was either proposed or elected, there would be a strong presumption that on the ground of usage women would not be eligible to such a society. He concludes by thinking that though under such circumstances a new charter would be strictly necessary, probably the needs of the case would be met by a bye-law or a general resolution at a special general meeting, and that the courts would not interfere with such a decision, even though it might not be strictly according to law.

Since this was written several societies have taken counsel's opinion on the subject, with many and diverse results. Indeed one eminent lawyer preludes his opinion with the remark that there is no certainty that a different mind might not view the question submitted to him in quite a different way. However that may be, at least two independent lawyers made the discovery that though probably the difficulty could be got over in the case of unmarried women, the fact of marriage would be fatal to their claims.

The ground for this opinion is that a married woman has no legal status, she is not a *person* within the usual phraseology of the charters, and so she cannot be a component part of a corporation. To this we may answer that numbers of married ladies are members of corporations in the shape of trading companies. We are left in doubt whether the corporate capability of a previously unmarried lady who had become a fellow would be crushed out of existence by her subsequent marriage. Presumably her name would be expunged from the register automatically, and her composition fee (if any) impounded! It is significant that in the new charter of the Linnean Society the words under which ladies are admitted are " such persons without distinction of sex," nothing being said as to whether they are married or unmarried. The Zoological Society took the bold course of dealing with the admission of ladies under a bye-law, their charter being of the ordinary kind, giving no indication one way or the other. I believe, however, that they always had lady fellows, though not till recently with full privileges. There seems to be now a general feeling, both lay and legal (apart from the married woman question), that it is not necessary to have a new charter, but that the simple course adopted by the Zoological Society is sufficient, namely, to pass a bye-law legalising the admission of women, provided there is nothing in the charter expressly or impliedly forbidding it. At any rate, it seems to be agreed that if this be done and women are elected, the courts will not interfere by injunction or otherwise, because no complaining fellow could show such an injury that the courts would take cognisance of. For it is clear that if the number of fellows of the society is by the charter unlimited, and no pecuniary question enters into consideration, the rights of an individual fellow are not impaired by the addition of one or more fellows, whether they be men or whether they be women.

I think I have now said enough on this somewhat complicated question, and with it I must bring my address to a close. I am afraid you will think that I have not said much about management, but much more about managers. If I have, it is because I hardly thought you would care to hear the small details of a council meeting, how many signatures are required to a cheque, or whether we should exchange publications with such and such a society. I have tried to treat the subject from a broad point of view, and have perhaps dealt more with societies in general than our own Association in particular. But I should like to remind you again that you have always placed singular confidence in your Council, and I think that must be from the respect you naturally feel for the efforts of that long series of honorary officials who have during nearly fifty years devoted their time and often their money to conducting your affairs. This feeling of contentment does not, however, exist in all societies, and I shall be quite satisfied if any remarks of mine should make any persons who are prone to discontent think a little more charitably of their councils; and I would ask them not to regard a hitherto blameless individual who may be put on the council as being thereby placed almost beyond the pale, not to look on the members of the council as mere office-seekers determined to keep everyone else out, but to try and think of them as individuals who approach their work animated by a feeling of duty and with a full sense of responsibility, having no other wish or design than to administer, without fear or favour, the affairs of the society with whose management they are entrusted.

ORDINARY MEETING.

FRIDAY, MARCH 1ST, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association:

H. E. Balch, Herbert V. H. Everard, Charles James Grist, M.A., Mrs. R. T. Sambrook.

A lecture was then delivered by Maurice Mancel Allorge, L. ès Sc., F.G.S., entitled "A Geologist's Impressions of Mexico." The lecturer gave a most interesting account of his visit to Mexico on the occasion of the meeting of the International Geological Congress of 1906. The lecture was illustrated by a series of lantern slides.

The President, on behalf of the Association, thanked Mr. Allorge for his excellent lecture.

VISIT TO THE BRITISH MUSEUM (NATURAL HISTORY).

SATURDAY, MARCH 2ND, 1907.

Director: DR. A. SMITH WOODWARD, F.R.S.

(*Report by* THE DIRECTOR.)

THE party of eighty-nine members was received by Dr. Woodward who pointed out some of the latest additions to the collection of Fossil Fishes, and discoursed on certain groups which were at that time exciting interest and attracting attention. His observations may be briefly summarised as follows.

The latest additions to the earliest known fish-like fossils (the so-called *Ostracodermi* or *Ostracophori*) are well-preserved specimens of *Drepanaspis*, from the Lower Devonian of Germany. These, and other similar fossils, prove that many of the supposed fragments of armour of sharks from the Upper Silurian and Devonian formations really belong to the much more primitive group of *Ostracodermi*. Equally primitive fish-like animals, with a hardened internal skeleton, instead of external armour, are represented by *Palæospondylus* from the Lower Old Red Sandstone of Caithness. Enlarged wax-models of this fossil, ingeniously made by Prof. W. J. Sollas, illustrate its structure very clearly.

A newly arranged large collection of Upper Devonian sharks (*Cladoselache*) from Ohio is interesting as exhibiting the internal skeleton, especially of the paired fins. Each fin is strengthened by simple parallel bars of cartilage—an arrangement of which the discovery was predicted when zoologists began to accept the hypothesis that paired fins in fishes are the remnants of a pair of lateral folds of skin. The teeth of some early sharks are also interesting, because they were not shed when they passed out of use, but remained in a fused mass in some way outside the mouth. Thus were produced spirals of teeth, which reached their greatest size and complication in *Helicoprion* from the Permo-Carboniferous of Russia and Japan. A plaster cast of one of the best specimens is exhibited.

The remarkable collection of *Dinichthys* and other armour-plated fishes from the Upper Devonian of Ohio was made by Dr. William Clark, of Berea, and is interesting for comparison with the European *Coccosteus*-like fishes. It shows that, just before the extinction of the race, these armoured fishes attained immense size, some with the dermal plates excessively thickened (*Dinichthys*), others with these plates comparatively thin (*Titanichthys*). Dr. Woodward still thinks that the extinct Coccosteans are related to the Dipnoi and to the Chimæroids.

A slab of Upper Old Red Sandstone from Dura Den, Fifeshire, is covered with examples of *Holoptychius Flemingi*, and evidently represents a shoal of this species suddenly destroyed and buried. Most well-preserved fossil fishes are obtained from definite thin layers, which appear to be the result of local accidents. Casual well-preserved specimens are very rare in all formations.

The fishes of the Coal Measures are usually found in the shales and ironstones accompanying the coal, very rarely in the coal itself. A few beautiful specimens, actually imbedded in coal from the Jarrow Colliery, Kilkenny, Ireland, are therefore of much interest. They were presented to the Museum by Mr. John Gerrard, F.G.S.

The fossil fishes of the southern hemisphere closely resemble those of the northern hemisphere, and exhibit a similar stratigraphical distribution. A typical *Acrolepis*, such as might have been obtained from the English Coal Measures, was discovered by Mr. A. J. C. Molyneux in the Sengwe Coalfield, Rhodesia, and parts of numerous specimens are exhibited in a large slab of ironstone. *Semionotus*, from the Stormberg Beds of South Africa, differs very slightly from the species of the same genus found in the Trias of Europe and North America.

The fish remains discovered by Mr. Alfred N. Leeds, F.G.S., in the Oxford Clay of Peterborough, form a remarkable collection. The bones can be removed from the matrix and be separately studied. As they belong to the same genera as the complete fishes found crushed though complete in the hard Lithographic Stone of the European continent, they can be studied with the latter and practically complete our knowledge of the skeleton of some of the extinct ganoids. The Oxfordian remains of *Lepidotus* and *Mesturus* are especially valuable in this connection. The tail of *Leedsia problematica*, also from the Oxford Clay of Peterborough, is the largest fish-tail known, about nine feet in span. Dr. Woodward thinks that *Leedsia* is related to *Hypsocormus*.

The fish remains from the English Chalk are usually fragmentary; but, like those of the Oxford Clay, they are important as displaying the separate bones. Whole fishes are commoner in the stratified and shaly chalk of Kansas, U.S.A., whence the Museum has obtained many fine specimens for comparison from Mr. C. H. Sternberg. This collection is continually being extended, the latest addition being a nearly complete pair of pectoral fins of *Protosphyræna*. These fins are noteworthy for the manner in which their constituent bony rays are arranged to produce the maximum strength and flexibility.

Most of the links between the Cretaceous and Tertiary fishes are still lacking. The sudden appearance of nearly all the modern types of bony fishes in the Eocene formations is very remarkable.

At the conclusion of Dr. Smith Woodward's remarks the President proposed that the thanks of the Association be accorded to him and this was carried unanimously.

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PROCEEDINGS
OF THE
Geologists' Association.

EDITED BY
HORACE WOOLLASTON MONCKTON.

(Authors alone are responsible for the statements in their respective Papers.)

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(*Continued on page 3 of the Cover.*)

ON THE EXISTENCE OF THE ALPINE VOLE (*MICROTUS NIVALIS*, MARTINS) IN BRITAIN DURING PLEISTOCENE TIMES.

(Read April 5th, 1907.)

By MARTIN A. C. HINTON

[PLATE I.

IN the year 1841, Martins and Bravais discovered a new species of Vole living at a great altitude on the Alps, which Martins subsequently described under the name of *Microtus nivalis.*[*] In 1852, Gerbe published an account of a closely allied animal from the Basses-Alpes which he called *M. leucurus*,[†] whilst in 1853 Wagner described yet another close ally from the Eastern Alps—*M. petrophilus.*[‡] An interesting account of *M. nivalis* and its two allies is given by Blasius.[§] None of these forms live to-day, so far as is known, at a smaller elevation than 3,000 feet above the sea. *M. leucurus* and *M. petrophilus* are characteristic of the lower peaks of the outer Alpine regions. *M. nivalis* inhabits the Central Alps, and from being very rare at comparatively low levels it becomes more and more frequent as one ascends, its maximum abundance being reached at or about the snow line. But far above this limit it may be found inhabiting little pinnacles of rock temporarily bared of snow and scantily clothed with the most stunted Alpine vegetation. In such places, says Blasius, it lives not merely through the short Alpine summer but through a hard Alpine winter of nine or ten months duration, secure under a covering of snow. In 1847, De Selys Longchamps[‖] showed that this remarkable species also inhabited the Pyrenees. It has since been discovered by Dr. Forsyth Major living on the summit of the Gran Sasso d'Italia, in the Abruzzi, at a height of 2,921 metres, and also in various parts of the Apennines.

It is evident from the remarkable habitat of this species, or rather group of closely allied forms, that all facts relating to its distribution in past times must be of considerable interest to the geologist. We are indebted to Dr. Forsyth Major for our earliest knowledge of *M. nivalis* as a Pleistocene mammal, for in 1873 he recorded its occurrence in the Grotta di Levrange in Lombardy, and in the Grotta di Parignana, near Pisa.[¶] He afterwards discovered its fossil remains in the Grotta di Verezzi in Liguria, and in the Grotta della Palmaria in the island of Palmaria, near

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[*] Martins, *Revue de Zool.*, 1842, p. 331; *Ann. d. Sc. Nat.*, 1843, xix, p. 87.

[†] Gerbe, *Revue de Zool.*, 1852, p. 260.

[‡] Wagner, *Münchener Gelehrt. Anzeig.*, 1853, p. 307.

[§] Blasius, *Säugethiere Deutschlands*, 1857, p. 359.

[‖] De Selys Longchamps, *Revue Zool.*, 1847, October.

[¶] Forsyth Major, *Atti. del. Soc. Ital. d. Sc. Nat.*, xv, pp. 375, 378, 389

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Spezia. Since then this species has been detected on numerous occasions among the fossil voles of the Continental Pleistocene deposits, as for example, by Dr. Nehring in the caves of the French part of Switzerland, and by Dr. Woldřich in the ossiferous fissures at Zuzlawitz in Bohemia and in Moravia.

Messrs. Blackmore and Alston in 1874* described a lower jaw of a vole from the brickearth of Fisherton, and gave a figure of the first lower molar. This they suggested might be referable to *M. nivalis*, but they hesitated to make a decided reference, as the teeth of *M. ratticeps* from the same deposit varied to such an extent as to render it possible that this example might be an extreme form of the latter species. I have not seen the specimen, but judging from the figure while the pattern of the *m.* $_1$ is somewhat similar to certain ill-defined forms of *M. nivalis*, yet it is not sufficiently distinctive to be regarded by itself as good evidence of the occurrence of this species at Fisherton.

In 1882, Mr. E. T. Newton† described and figured a lower jaw from the Upper Freshwater Bed at West Runton, in which the anterior loop of the first lower molar is suggestive of some of the forms of *M. nivalis.* Mr. Newton did not record the species as a Forest Bed form, regarding the evidence as too meagre, but in any case all possibility of such a reference is precluded, since, as Dr. Forsyth Major first pointed out to me this jaw, in common with the others figured on Pl. xiv of Mr. Newton's work, does not belong to the subgenus *Microtus*, the *m.* $_1$ of which possesses five closed triangles, but to *Pitymys*, a subgenus in which the anterior lower molar is composed of a posterior loop followed by three closed triangles, which are followed in turn by an outer and an inner triangle communicating widely with each other and shut off from the anterior loop, completing the tooth in front.

In 1899, Mr. E. T. Newton‡ provisionally referred certain of the lower jaws from the Ightham Fissure to *M. nivalis.* He says: "The front lower cheek tooth of this species is not always to be clearly distinguished from extreme forms of *M. glareolus;* but among the very many examples of the latter species which have been obtained by all the collectors from the Ightham Fissure. there are several which have the inner part of the anterior prism well developed, so that five inner and four outer angles may be counted. It seems highly probable, therefore, that these are the remains of *M. nivalis.*" Six of the specimens so referred to are in the collection of Messrs. Corner and Kennard, and these I have carefully examined. Those which belong to old enough individuals have the teeth distinctly rooted, and all have the murine incisor root so characteristic of *Evotomys*, and which is quite different in *Microtus*.[*] Therefore, these remains cannot be referred to *M. nivalis*, but clearly belong to *Evotomys glareolus*.

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* Blackmore and Alston, *Proc. Zool. Soc.*, 1874, p. 466, fig. 2*g*.

† Newton, E. T., "Vertebrata of Forest Bed." *Mem. Geol. Surv.*, p. 90, Pl. xiv, fig. 7.

‡ E. T. Newton, *Quart. Journ. Geol. Soc.*, lv, p. 425.

In 1901, in the report of an excursion of this Association to Grays,[†] I recorded the occurrence of *M. nivalis* in the brick-earth of that locality. This record was based upon a detached $m._{\overline{1}}$, and a further prolonged study of this tooth has convinced me of the accuracy of this determination. The specimen is again referred to in the sequel, and so far as I know this was the first well-founded record of *M. nivalis* as a former inhabitant of Britain.

The difficulty which obviously exists in determining the remains of this species, arises from the fact that one, in determining the fossil remains of voles, and particularly those obtained from fluviatile deposits, has to rely practically wholly on the evidence afforded by the pattern of the first lower and third upper molars. Now the $m._{\overline{1}}$ of some varieties of *M. nivalis* is occasionally very difficult to distinguish from the extreme forms met with in such species as *Evotomys glareolus*, *M. arvalis*, *M. agrestis* and *M. gregalis*. With regard to the $m.^{\underline{3}}$, its typical recent form is usually distinctive enough, but unfortunately this form appears to be very rare in the British deposits.

It is necessary to here allude to one or two points connected with the structure of microtine molars in general, as they throw a good deal of light on certain problems connected with the variations in form seen in the two diagnostic teeth, viz.: the $m._{\overline{1}}$ and the $m.^{\underline{3}}$. It has long been known that the investing enamel sheet is not of equal thickness throughout; that in lower molars it is thicker on the anterior walls of the prisms than it is on the posterior ones, and that the converse to this holds good as regards the upper molars.[‡] Dr. Forsyth Major has demonstrated the fact that in well-worn teeth the enamel sheet entirely disappears at one point in the anterior loop of the $m._{\overline{1}}$, and also in the posterior loop of the $m.^{\underline{3}}$.[§] Consequently the comparatively soft dentine here appears as forming part of the periphery of the tooth, and, being no longer constrained by the enamel, runs riot, and most extensive variations of form are the result. Practically all the specific distinctions to be demonstrated in the dentition of the subgenus *Microtus* are drawn from the variable parts of these two teeth, *i.e.*, their terminal loops. The fact that the terminal loops vary so greatly throughout the subgenus is really not so surprising as the equally well-attested fact that on the whole the variations observed very constantly range themselves round certain

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[*] Nehring, *Zeits f. ges. Naturwiss.* Bd. xlv (1878), p. 235.

[†] Hinton, *Proc. Geol. Assoc.*, xvii, p. 142.

[‡] See for example the figures given by Dr. Merriam in *N. Am. Fauna*, No. 2, Pl. iv, etc.

[§] Forsyth Major, *Proc. Zool. Soc.*, 1902, vol. i, p. 106, text fig. 15, fig. 27, and in many of the teeth of *Mimomys* there figured.

points, and that these points coincide in general with species, and, in some cases, even with varieties founded often on quite other characters. Dr. Rörig and Dr. Börner, in a recent elaborate paper [*] enter very exhaustively into the subject of the inequalites of the enamel sheet, evidently thinking themselves the first to observe these features. They say that the enamel becomes a very thin continuous band in the terminal loops of $m._{\overline{1}}$ and $m.^{\underline{3}}$, but this is hardly an accurate statement, for except in very young teeth careful examination will, as a rule, show it to be entirely absent as above stated.

Several authorities, among whom may be mentioned Woldřich, and Rörig and Börner, have asserted that certain series of all but insensible variations may be traced, which lead from one species with a comparatively simple molar pattern, through other species to a form characterized by molars of a more complex type. Although not in a position to discuss this question fully on the present occasion, I wish to briefly allude to it, as it is of importance to the palæontologist. Woldřich's researches were conducted principally on a large series of fossil jaws from the Moravian Caves.[†] Inspection of his numerous figures will show that not only are some of the variations very discontinuous, but that his arrangement of the series is quite an arbitrary one in many cases, various alternative arrangements being open to us, so that we may proceed to any given point in the series by very different routes. Rörig and Börner [‡] on the other hand have argued that the dental pattern supposed by palæontologists to characterize *M. gregalis* occurs also in the *arvalis* group of species as an individual variation. This, I venture to think, is not a serious objection to the diagnostic value of the molar pattern for two reasons; firstly, because *M. gregalis* is precisely that recent species of which we possess the minimum of knowledge; and secondly, whether the pattern supposed to differentiate its $m._{\overline{1}}$ from all other species occurs in the *arvalis* group or not, there can be no doubt that the great majority of the *arvalis* individuals possess a pattern peculiar to their own group, and different from the pattern of *gregalis*. The general principle that in so far as each group of species possesses a pattern, on the whole peculiar to itself, which is shared by the great majority of its individuals, such patterns are diagnostic of species is, in my opinion, very difficult to assail, although at the same time it is not always safe to record a species upon an isolated tooth, since the diagnostic pattern may occur, though very rarely, in abnormal individuals of other groups.

The $m._{\overline{1}}$ of *M. nivalis* consists essentially of a posterior loop—five more or less completely closed triangles and an anterior loop—these elements being common to this tooth in the whole subgenus *Microtus*. The posterior loop and the closed triangles or prisms afford us no distinctive characters unless it be that the angles terminating the prisms are somewhat sharper than is usual in most other species. In the form called *M. petrophilus* there is a tendency for the hind wall of the prisms, and especially those of the outer side, to become bilobed.* The principal distinction must be drawn, however, from the form and composition of the anterior loop. If we examine this part of the $m._{\overline{1}}$ of *M. nivalis* we find that the outer and inner posterior walls of the anterior loop are formed of thin enamel, and that they correspond to the posterior walls of the fourth outer and fifth inner prisms respectively. From the junction of the inner posterior wall with the inner side of the anterior loop we find a band of very thick enamel extending forwards to near the antero-internal extremity, where it ends off abruptly. This we immediately recognise as the anterior wall of the fifth inner prism turned from the transverse position held by its predecessors into a longitudinal one. Similarly on the outer side we find a stretch of very thick enamel, the anterior wall of the fourth outer prism, but which does not extend so far forwards as its companion of the inner side, though, like the latter, it ends off quite abruptly in front. Between the abrupt terminations of these stretches of thick enamel there is a broad arcuate expanse of dentine, forming the periphery of the triturating surface, and which in the well-worn crown is entirely free from any investiture of enamel (Plate I, Figs. 1, 7, 10, and 18). Thus it is clear that no rudiment of either a sixth inner nor a fifth outer prism enters into the composition of the anterior loop of *M. nivalis*. The fifth inner and the fourth outer prisms, each considered as a whole, are turned obliquely backwards out of the normal lateral position to a greater or less degree—a character which attains its highest expression in the typical *M. nivalis* and in *M. imitator*, Bonhote.† Sometimes only one of the prisms shows this axial revolution. Its tendency is to increase the length of margin formed by dentine alone. The anterior loop may be completely closed behind or pretty widely confluent with the fourth inner prism.

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[*] Rörig and Börner, *Arb. a.d. Kais. Biol Anstalt f. Land-und Forstwirthschaft*, 1905, Band v, pp. 37-79.

[†] Woldřich, *Sitzb. d. k. Akad. Wien, Math. Nat. Cl.*, Bd. 90, p. 387.

[‡] Rörig and Börner, *op. cit.*, pp. 71-78.

Apart from its rooted condition the $m._{\overline{1}}$ of *Evotomys* distinguishes itself by the fact that the fifth inner angle is usually rudimentary, by the more concentrated and confluent character of the whole tooth, and also by an interesting tendency to bilateral complication of the posterior loop—a variation to be frequently seen in this remarkable genus, but of extremely rare occurrence in *Microtus*. The possession of five closed triangles by the $m._{\overline{1}}$ of *M. nivalis* at once, of course, distinguishes this tooth from any of the subgenera, *Pedomys*, *Pitymys*, *Arvicola*, etc.

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* Blasius, *Säugethiere Deutschlands*, p. 360, fig. 196. The figure shows this feature on the second inner prism of *m.* 2.

† Bonhote, *Ann. & Mag. Nat. Hist.*, Ser. 7, vol. xv, pp. 197-199.

The species from which it is necessary to carefully distinguish *nivalis* are *M. ratticeps*, *M. arvalis*, *M. agrestis*, *M. gregalis*, etc. In the *m.* $_{\text{I}}$ of *M. ratticeps* the fourth inner prism is widely confluent with the anterior loop; the fourth outer is very feebly developed and usually only present in a flattened-out condition forming an enamel wall to the anterior loop. The fifth inner shows no backward turning, and there may be a small sixth inner prism.

The *m.* $_{\text{I}}$ of the typical *M. arvalis* distinguishes itself at once by the fact that the fifth inner and fourth outer prism if not shut off are yet quite distinct from the anterior loop, and do not help to form it. There is often a sixth inner and a fifth outer prism. In some varieties the fifth inner tends to merge with the anterior loop, but there is no backward turning and consequently the anterior loop is very different in form to that of *M. nivalis*. Sometimes the fourth outer prism shows a backward turning, but this usually results in more distinctly separating the prism from the anterior loop. Certainly nothing is seen either in *M. arvalis* or in its near ally, *M. agrestis*, which ever approaches the typical *M. nivalis*, *M. leucurus*, or *M. petrophilus*, and such forms as do come near some of the ill-defined teeth of *M. nivalis* show on examination either an extra prism in front or some difference in form which satisfactorily serves to distinguish them.

The group of voles in which the distinction of the *m.* $_{\text{I}}$ from that of *M. nivalis* presents the greatest difficulty is undoubtedly that which may be regarded as represented by *M. gregalis*. And here the difficulty is felt, not when dealing with the typical forms, for they are distinct enough, but when dealing with some of the ill-defined teeth occasionally met with, especially in the *M. leucurus* and to a less degree in the *M. petrophilus* sections of the *M. nivalis* group.

The typical *m.* $_{\text{I}}$ of *M. gregalis* distinguishes itself from this tooth in other groups by some very characteristic features. The third outer infold or cement space is wide and to a lateral view quite open. The result of this is that its anterior wall passes into the anterior loop without forming a backwardly projecting angle and usually without forming a fourth outer angle at all. The external border of the anterior loop is much elongated and approximately straight; this is well seen in the figures given by Woldřich,[*] Newton,[†] and others. On its inner side the anterior loop develops one or two angular projections, thus giving rise to a fifth or even a sixth inner angle; and this fifth inner angle never shows the backward turning so frequently seen in *M. nivalis*. In addition, the thick parts of the enamel are usually appreciably thinner than in *M. nivalis*. The long, straight anterior loop is well seen even in the "arvaloid" form of Dr. Woldřich[*] where a fourth outer angle is developed. I have examined at one time or another a great number of fossil jaws referred to the *M. gregalis* group, and as far as my experience goes the variation is principally confined to the development or absence of a small sixth inner angle, the degree of openness of the third outer infold which varies within quite narrow limits, and the extent to which the long, straight outer wall of the anterior loop tends to become curved or broken up into small angular waves.

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[*] Woldřich, *Sitzb. d. k. Akad. Wien, Math. Nat. Cl.*, Bd. lxxxii, Abt. ii, Taf. ii, fig. 12, Bd. lxxxiv, Abt. i, Taf. ii, fig. 48.

[†] Newton, *Quart. Journ. Geol. Soc.*, vol. l, Pl. xi, fig. 12a.

It is now necessary to detail the evidence upon which my determination of the *M. nivalis* group as a constituent of the British Pleistocene fauna is based. The remains yielded by the deposits of the Lower Thames Valley will be first noticed, and afterwards those from other localities will be dealt with.

All the nivaloid remains so far known from the Thames deposits have been obtained from the brickearths of the Middle Terrace. There is no trace of *M. nivalis* among the few vole remains known from the High Terrace deposits, but little or nothing can be based on this because not only are fossiliferous sections in these deposits exceedingly scarce but Dr. Forsyth Major[†] has already shown that a nivaloid vole occurs in the far older Upper Freshwater Bed of West Runton, so that we may conclude that the *nivalis* group first established itself in Britain in late Pliocene times.

GRAYS THURROCK.

As already mentioned, I recorded the occurrence of *M. nivalis* in the Grays brickearth in 1901. The record rests on a right *m.*$_1$ possessing a short anterior loop with a somewhat angulated antero-internal extremity, thus resembling the recent *M. petrophilus* (Pl. I, fig. 5). Comparison with Dr. Forsyth Major's figure will show that the specimen stands about midway between *M. nivaloides* of the West Runton deposit and *M. petrophilus*.

CRAYFORD AND ERITH.

The brickearth of Crayford and Erith has yielded remains referable to the *M. nivalis* group in abundance, associated with such other voles as *M. ratticeps*, *gregalis*, and at least two members of the *gregalis* group which are new to science, *Arvicola amphibius*, and the Lemmings. Numerous examples are contained in the collections of Mr. A. S. Kennard, Mr. G. White, and myself, and I daresay others occur in several Crayford collections which I have not yet examined. Mr. White's specimens were obtained from the great Crayford pit, while Mr. Kennard collected from the new pit to the north of this. My best thanks are due to both these gentlemen for the kindness with which they placed their collections at my disposal.

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[*] Woldřich, *op. cit.*, Bd. lxxxiv, Ab. i, Taf. ii, fig. 47.

[†] Forsyth Major, *Proc. Zool. Soc.*, 1902, vol. i, p. 106, text-fig. 15, fig. 19.

One of the most characteristic examples I have seen is a right $m._{\overline{1}}$ in Mr. White's series (Pl. I, fig. 6). The short arrow-head-shaped anterior loop is very similar to some of the recent examples from Italy, kindly lent to me by Dr. Forsyth Major while the slightly angulated antero-internal extremity of the loop resembles what is seen in *M. petrophilus.* A left $m._{\overline{1}}$ in Mr. White's collection affords a very good illustration of another type of *M. nivalis,* characterised by a rather long-pointed anterior loop, the fourth outer and fifth inner prisms being turned backwards (Pl. I, fig. 7). This tooth is very much like the form figured by Rörig and Börner (*op. cit.*, fig. 44*d*). A right $m._{\overline{1}}$ in my collection shows a somewhat similar form, in which the anterior loop is very long, and the thick enamel on the outer side—*i.e.*, the anterior wall of the fourth outer prism preserves some of its primitive concavity—a character which allies the specimen with a well-marked form or species of the *nivalis* group, which will be described later on (Pl. I, fig. 8).

A right $m._{\overline{1}}$ in Mr. White's collection (Pl. I, fig. 9) shows a *M. leucurus*-like form, the fourth outer prism not being produced backwards into a prominent angle. A very fine right $m._{\overline{1}}$ in Mr. Kennard's collection shows pronounced backward revolution of the fourth outer and fifth inner prisms, and, moreover, admirably illustrates the parts which the thick enamel walls and bare dentine play in the structure of the anterior loop (Pl. I, fig. 10).

The anterior half of a right ramus in Mr. White's collection contains the $m._{\overline{1}}$ and $m._{\overline{2}}$ (Pl. I, fig. 11). The former tooth is interesting, recalling as it does in some respects the $m._{\overline{1}}$ of the Kashmir species, *M. imitator*, recently described by Mr. Bonhote. The $m._{\overline{2}}$ of this specimen has the anterior prisms confluent with each other.

An imperfect right ramus presented to the Museum of Practical Geology, by Mr. Kennard, contains the $m._{\overline{1}}$ (Pl. I, fig. 12); the form of the anterior loop approaches the Clevedon species to be described later. It remains to notice some specimens from Crayford which approach *M. leucurus* in form.* These have a wide open third outer infold, not unlike that of *M. gregalis*, and the fourth inner prism is more or less confluent with the anterior loop, as in *M. ratticeps*, but the thick enamel of the outer side, *i.e.*, the anterior wall of the fourth prism and the structure of the inner side of the loop, satisfactorily distinguish these teeth from the $m._{\overline{1}}$ of either of the species mentioned. I have drawn two of these specimens, one belonging to Mr. White and one to Mr. Kennard (Pl. I, figs. 13 and 14). One

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* *Cf.* Woldřich, *Sitzb. d. k. Akad. Wien, Math-nat Cl.*, Bd. lxxxiv, Abt. I, Taf. II, fig. 28.

(fig. 14) is interesting, as showing a little thin enamel following the thick stretch on the inner side, the tooth having belonged to a young individual.

WICKHAM.

In the Spurrell collection (Museum of Practical Geology, No. 5649) the anterior half of a left ramus containing the *m.* $_1$ is preserved. The specimen is of very large size, and I have had some difficulty in making up my mind as to its affinities. The form and structure of the anterior loop probably indicate a species of the *nivalis* group (Pl. I, fig. 15). The enamel is very thick, and I believe the jaw to belong to a form distinct from any of those hitherto noticed, but which in some respects approached *M. leucurus* and in others *M. malei*—the new species which is described later from the Clevedon cave. I have preferred, however, to wait for further material before bestowing a new name upon this jaw.

With regard to the deposits other than those of the Thames I have so far made a detailed search for the Alpine vole in the collections from two localities only, viz., the Ightham Fissure and the cave near Clevedon, in Somersetshire, which has lately been investigated by Dr. Male, his brother, and Prof. Reynolds. As regards the Ightham Fissure there is, so far as I have yet been able to ascertain, no evidence of the presence of *M. nivalis* there, and this fact, as I shall endeavour to show in the sequel, goes far to prove the late Pleistocene age of that deposit.

CLEVEDON CAVE.

Dr. H. C. Male very generously presented me with a small series of the numerous jaws of *Microtus* which he found in the Clevedon deposit. After a very careful examination of this material I came to the conclusion that a large vole belonging to the *nivalis* group was represented among the cave fossils. On my informing Dr. Male of my opinion he kindly placed the remainder of the collection in my hands for investigation. Mr. E. T. Newton had previously examined this series, and had sorted the specimens out into the *M. ratticeps*, *M. gregalis*, and *M. nivalis*-like forms, and I should state here that in the shortness of the time which I had at my disposal to devote to this large series Mr. Newton's work was of the greatest value to me, because it enabled me to go direct to the points upon which I required evidence. To both Dr. Male and Mr. Newton I would here tender my warmest thanks.

The nivaloid voles from Clevedon may be divided into two series, viz., those referable to existing members of the group, and those in my opinion belonging to a distinct and hitherto unknown form.

(*a*) Jaws indistinguishable from recent forms of the *M. nivalis* group.

The first specimen to be noticed is the anterior portion of a right ramus containing the $m._{\overline{1}}$ and $m._{\overline{2}}$ and the incisor. The pattern of the $m._{\overline{1}}$ (Pl. I, fig. 16), is very distinctive of *M. nivalis*, and as regards the anterior loop is intermediate in form between the teeth shown in fig. 44*d* and *c* of Rörig and Börner (*op. cit.*). With regard to the $m._{\overline{2}}$, the second outer infold does not meet the enamel wall of the opposite side, but on the other hand more nearly does so than is usual in recent *M. nivalis*. However, there is a good deal of variation among recent individuals in this respect. Another very fragmentary right ramus containing the $m._{\overline{1}}$ supplies us with similar evidence. Unfortunately, three of the inner prisms are badly mutilated, but the anterior loop is intact. This (Pl I, fig. 18), agrees perfectly with one of the forms figured by Rörig and Börner (fig. 44, *d*, *op. cit.*), and can only be referred to *M. nivalis*. The presence of a *petrophilus*-like form at Clevedon is shown by a fragment of a right ramus containing the $m._{\overline{1}}$ and $m._{\overline{2}}$, the former with the characteristic short anterior loop (Pl. I, fig. 19). The *M. leucurus*-like form which we have already seen to occur at Crayford, is also represented among the Clevedon forms. Two rami, a right and a left, each containing the $m._{\overline{1}}$ and $m._{\overline{2}}$, and each, unfortunately, wanting the hinder part, are certainly referable to this form. The $m._{\overline{1}}$, though differing in slight details in each specimen, exhibits a structure very similar to that of the Crayford specimens (Pl. I, figs. 20-21). The $m._{\overline{2}}$ is as in normal *Microtus*, *i.e.*, the second outer infold advances far enough across the crown to substantially shut off the two anterior prisms from each other. Other examples referable to one or other of the nivaloid forms are seen in figs. 17 and 22.

(*b*). Nivaloid jaws not referable to existing members of the *M. nivalis* group.

We now have to consider a series of jaws which, although referable to a large member of the *nivalis* group, present certain features which appear to be sufficiently distinctive to justify a separate specific designation. I have made very careful drawings of a representative set of the first lower molars of this series (Pl. I, figs. 23-29). Inspection of these drawings will show that the $m._{\overline{1}}$ of this form distinguishes itself from that of the other members of the *nivalis* group; firstly, by the greater or less development of the antero-internal extremity of the anterior loop, so as occasionally to form a slight sixth inner angulation; secondly, the thick enamel of the outer wall of the anterior loop, *i.e.*, the anterior wall of the fourth outer prism retains the concavity which characterises the anterior walls of normal prisms, and this feature, of course, enhances the apparent projection of the fourth outer angle. With these modifications of structure the anterior loop of the *m.* $_1$ of the Clevedon species usually combines great breadth. For this new form I venture to propose the name of *M. malei*, in order to associate it with the gentleman to whom I am indebted for the material enabling me to define it.

It is of interest to notice that *M. malei* is represented in the deposits of the Thames Basin. Thus Dr. Forsyth Major showed me the *m.* $_1$ of a vole from Wickham in the British Museum which appeared to be indistinguishable from the Clevedon species, while in Mr. White's collection from Crayford there is a right *m.* $_1$ which only differs from the Clevedon specimens in the somewhat slighter depth of the fourth inner infold or cement space (Pl. I, fig. 29). Some of the examples in Mr. Kennard's collection, also, as already mentioned, approach this form.

THE SKULL AND *m.* ^{3}.

The skull in the *M. nivalis* group, as is well known, presents certain aberrant characters which, taken in conjunction with the dentition, strongly mark the group off from the other sections of the subgenus *Microtus*. It is therefore to be regretted that hitherto no example from British deposits has been preserved. This is a desideratum which the caves and fissures of Somersetshire will probably supply.

With regard to the *m.* ^{3} this tooth in recent *M. nivalis* usually possesses a pattern of three inner and three outer angles (Pl. I, fig. 2a). I have so far looked in vain for a last upper molar of this type among the British specimens. Very few maxillary teeth were preserved from the Clevedon Cave, so that the specimens before me from that locality may belong to some of the other species of *Microtus* which occurred in the cavern. Numerous examples are before me from Crayford, and of these some, I think must belong to *M. nivalis*. Yet they all differ from the usual recent form in having the internal corner of the posterior loop angulated so that there are four inner angles instead of three. The *m.* ^{3} of a young skull of recent *M. nivalis* from Monte Cimone in the collection of Dr. Forsyth Major possesses the rudiment of such a fourth inner angle (Pl. I, fig. 1a), and this seems to suggest that the fourth inner angle is a disappearing structure in the *M. nivalis* group, since it may have been permanently developed in the adult *M. nivalis* of Pleistocene England but now is only met with in the young individuals. In the eastern part of the range of the group, *i.e.*, in Kashmir, a nivaloid vole, *M. imitator*, Bonhote, occurs which possesses a last upper molar of still more complicated form than that which may have characterised the *m.* ^{3} of our Pleistocene races, since this tooth has four outer as well as four inner angles.*

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* Bonhote, *Ann. & Mag. Nat. Hist.* Ser. 7, vol. xv, p. 198.

MEASUREMENTS OF THE JAWS CONTAINING THE TEETH FIGURED IN PLATE I.

SPECIMEN.	1	2	3	4	SPECIMEN.	1	2	3	4
Monte Cimone, fig. 1	4.75	3.03	2.6	3.99	Clevedon Cave, fig. 22	4.11	3.74	2.98	4.82
Monte Cimone, fig. 2	3 91	3.4	2.9	4.8	Clevedon Cave, fig. 19	3.4	3.18	3.09	4.92
Crayford, fig. 14	3.68	3.58	2.91	=	Clevedon Cave, fig. 23	6.08	4.14	3.31	4.92
Crayford, fig. 11	4.28	3.52	2.79	4.28	Clevedon Cave, fig. 24	4.76	4.33	3.22	4.82
Crayford, fig. 12	4.52	3.76	3 3	=	Clevedon Cave. fig. 25	4.48	=	3.1	5.1
					Clevedon Cave fig. 26	5.68	3.94	2.98	4.76
Clevedon Cave, fig. 16	4.28	=	3.07	4.96	Clevedon Cave, fig. 27	5.05	4.6	3.17	5.27
Clevedon Cave, fig. 17	4.63	4.14	2.61	3.84	Clevedon Cave, fig. 28	4.15	4.07	2.9	4.53
Clevedon Cave, fig. 18	4.25	4.3	2.97	=					
Clevedon Cave, fig. 20	3.84	3.7	2.22	4.33					
Clevedon Cave, fig. 21	3.48	4.14	2 91	4.38	Wickham, fig. 15	4 9	=	3.73	4.97

(1) Length of diasteme.
(2) Height of ramus at fourth inner prism of *m.* $_{1}$.
(3) Length of *m.* $_{1}$ (alveolar).
(4) Length of *m.* $_{1}$ and *m.* $_{3}$ along alveolar border, inner side.
The measurements are in millimetres and were made with the camera lucida and 5 inch objective.

CONCLUSION.

In my opinion the evidence that has been detailed in this paper renders it practically certain that the *M. nivalis* group of voles was strongly represented in Britain during Pleistocene times, and we have therefore to consider what bearing this fact has on our ideas of Pleistocene history. Examining the present distribution of this group of voles, one finds that all the existing forms are creatures inhabiting high altitudes, and that as a general rule we may say that the greater the altitude the more abundant is *M. nivalis*. It seems thus to be a group incapable of flourishing far from the vicinity of perpetual snow, and therefore we may argue that at the time it so abundantly peopled certain localities of England those neighbourhoods must have suffered a climate much more severe than that obtaining at the present day. Yet I believe that this conclusion, sound as it may superficially look, is really a false one, and that we only arrive at it by reasoning from premises unnaturally limited. In order to obtain an accurate notion of the story which this or any other group of animals has to tell the geologist we must take into consideration not only the facts relating to the habits and distribution of its living members but all the facts relating to its past history, and to the histories of its former and present contemporaries which we may be able to acquire. In other words, the wider the scope of our premises the more accurate will our deductions tend to become.

It is first necessary to examine, with some care, the earliest microtine fauna of Britain. In the Norwich Crag we meet with the earliest English voles, here represented only by that remarkable genus *Mimomys*, whose history, first outlined by Mr. Newton in 1882,* has since been admirably investigated by Dr. Forsyth Major.† The teeth found in the Norwich Crag are plainly, for the most part, not contemporary with that deposit, but have been derived from some older bed, which, so far as our knowledge goes, is now totally destroyed. The principal species found in the Norwich Crag occurs also in the Pliocene deposits of the Val d'Arno. The voles of the genus *Mimomys*, are characterized by rooted molars, and the $m._{\overline{1}}$ is a tooth which, originally possessing three outer infolds or cement spaces, suffers a progressive atrophy of the third or anterior one. It is a general rule, that the atrophy of any valley intersecting a molar tooth proceeds by a gradual growing or knitting together of its enamel walls, and consequently, as the tooth is worn down, internal portions of the valley or cement space become isolated from external portions and form little detached enamel rings or fossettes on the worn triturating surface, which thus serve to mark the former extent of the valley. Continued wear finally obliterates these enamel rings and then no trace of the former valley can be seen. In species which stand near the starting point of the valley degeneration such internal enamel rings may penetrate the crown to a great depth, and consequently they will persist through a very long portion of the life of the tooth. In the Norwich Crag species, *M. pliocænicus*, this is the case, as is shown by Dr. Forsyth Major.

Coming now to a still later point in Pliocene time, that marked by the East Runton deposit, we find that *Mimomys* still alone represents the voles. Its $m._{\overline{1}}$, however, has degenerated a little further, for the enamel islet tends to disappear at an earlier stage of wear, while, on the other hand, the development of roots is a little more tardy.

In the still later Upper Freshwater Bed of West Runton we meet with *Mimomys*, but now the enamel islet is only found in young teeth. Here, too, the genera *Evotomys* and *Microtus* make their first appearance in England. Two sub-genera of *Microtus* are represented, viz., true *Microtus* and *Pitymys*, most of the remains found belonging to the latter.

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* Newton, "Vertebrata of the Forest Bed," p. 83.

† Forsyth Major, *Proc. Zool. Soc.* (1902), vol. i, pp. 102-107.

Whence came these voles? We may infer from the fact that *Mimomys* occurs in the Italian Pliocene that it came from the south, and it seems probable that the other three sections had their original home in Central or South-Central Asia, and that they spread eastwards and westwards so as in later times to acquire a more or less circumpolar distribution, reaching America by North-Eastern Asia, and Western Europe by Asia Minor and Southern Europe. *Pitymys* is especially a good instance in support of this claim for a southern origin, for to-day, driven back from its more northern outposts, it finds a refuge in the home of its immediate ancestors, viz., in Southern Europe. Among the few representatives of true *Microtus* from the West Runton deposits, we find the earliest English member of the *nivalis* group—*M. nivaloides*, Major. The *nivalis* group is essentially a southern one, ranging as it does from Kashmir to the Pyrenees, not occurring north of the Alps, and although in Pleistocene times its range extended as far west as Somersetshire, it appears at no time to have gone farther north than Norfolk or Southern Germany. The point I wish to make on these facts is that we do not owe our late Pliocene or early Pleistocene microtine fauna to the Siberian migration at all, as Dr. Scharff suggests,* but that they came to England from Southern Europe long prior to the arrival of the Siberian forms.

Between the deposition of the Forest Bed series and that of the High Terrace drift of the Thames an enormous interval of time must have elapsed—a gap unspanned by any English mammaliferous deposit, unless, indeed, certain of the cave deposits, such as those containing remains of *Machairodus*, are to be referred to this age. The fauna of the High Terrace drift, so far as it is known, has a good deal of affinity with the Forest Bed series. The voles represented are *Mimomys*, which was detected some years ago by Mr. White and myself,† and *Evotomys*. The *Trogontherium* has been determined by Mr. Newton, and it is noteworthy that the Red-deer which occurs is a small form, being accompanied by a large form of Fallow-deer. This fauna I hope shortly to fully describe, but it suffices to say now that it does not show the mixture of northern and southern forms so characteristic of the later Pleistocene deposits, and which has been so hard to explain.

Of the later Pleistocene deposits the most important series for our purpose is undoubtedly that formed by the Middle Terrace drift of the Thames, for from no other horizon have we obtained so complete and varied a picture of the Pleistocene mammalian fauna. And here at last we meet with evidence of the invasion of England by swarms of mammals which can only have come from Siberia and Eastern Europe. To this invasion must be ascribed

* Scharff, "History of the European Fauna," p. 201.

† Hinton and White, *Proc. Geol. Assoc.*, vol. xvii, p. 414.

the presence of the Lemmings, the numerous species of the subgenus *Microtus*, such as *ratticeps*, *arvalis*, *agrestis*, and the great group of *gregaloid* voles, the genera *Cricetus*, *Spermophilus*, and *Lagomys* among the Rodentia, and of the barren-ground Reindeer, and *Saiga* Antelope among the Herbivora. Some of the older forms, such as *Mimomys*, *Trogontherium*, and the large Fallow-deer had at this stage apparently entirely disappeared, but many others, *e.g.*, the *nivalis* group, continued to flourish.

This brief statement of facts will suffice for the moment, and it is necessary now to examine the question of the climatic conditions of Pliocene and Pleistocene England. The mammalian fauna of the late Pliocene deposits, and that of the High Terrace deposits teach us that during the periods which they represent the climate of Britain must have been a genial one. It is not until late Pleistocene times that the mammaliferous deposits begin to give us contradictory evidence on this point. Here, as we have seen, we first meet with those northern and eastern forms in such numbers as to lead one to postulate cold conditions in order to account for their existence in this country. At the outset it must be admitted that if we have regard only to the present distribution of these cold-forms, if, for example, we take the occurrence of the Arctic Lemming, and recognise that to-day it is confined to high northern latitudes, and that it almost studiously avoids even the scanty shelter of the dwarf birches, which extend far beyond the northern tree limit into the southern parts of its distributional area, it requires no strong effort of the imagination to conjure up the former existence in Britain of Arctic Tundra and sub-Arctic Steppes. And in Germany and Austria, where such evidence becomes still more striking, we, in taking stock of these facts only from the recent habitat standpoint, are almost compelled to adopt such views as those so ably advocated by Prof. Nehring,* Dr. Woldřich† and others. But, unfortunately for the Steppe and Tundra theory, so far at least as Britain is concerned, there exists a large body of undeniable evidence in the other scale, and the acceptation of the theory, moreover, would be in direct conflict with what we now know to have been the actual physical geography of Britain in late Pleistocene times.

Side by side with these new Steppe-forms there flourished in the south of England the old group of southern forms. No doubt, as to day, the different mammals chose places suitable to their different modes of life—those species which preferred the woodland would seek it, and those who disliked it would inhabit the barer uplands. Indeed, as I hope to show on another occasion, we have actual evidence of this selection of localities in the Thames deposits. The cold, which at first sight appears to be necessary to the existence of the Arctic Lemming, would render the existence of the Hippopotamus and Ape impossible, and yet we know that all three animals, and many others having requirements similar to the one or the other type, managed to exist at one and the same time in Southern England. Temperature, we have been often told, is the principal factor governing the distribution of mammals, and it may be conceded that in some cases it is so. The assertion is certainly true, universally, to the extent that an Arctic mammal can no more endure the torrid zone than a torrid mammal a boreal clime. But at the same time one must recognise numerous other factors, as for example, food supply (which probably is the *only* universal governing factor), or the distribution of disease. And when, as in the present case, we are endeavouring to write the history of a remote time where the evidence given by the species which were then living, *qua* temperature, is of so contradictory a nature, pointing, as it does, to two diametrically opposed extremes, surely the right inference is that the temperature cannot have been extreme at all, but that the winters must have been mild to suit the southern forms, and the summers cool in order to accommodate the northern species. To my mind, therefore, the real problem to be solved is not as to what climatic conditions held sway in Britain during the joint tenancy of the northern and southern mammalia, but the question as to what it was that, at a later time, drove some forms northwards, others southwards, and still others to the mountain tops.

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* Nehring, *Ueber Tundren und Steppen*, Berlin, 1890.

† Woldřich. *Mitth. d. Wiener Anthrop. Ges.*, Bd. xi., p. 183, and papers already cited.

In this paper we are concerned only with the voles, but in substance the argument is applicable to the other Pleistocene mammalia. Briefly put my contention amounts to this : that in order to explain the differences in distribution which have been effected since Pleistocene times it is not necessary to invoke any substantial change in climate, and that on the other hand all such differences can be satisfactorily accounted for by taking into consideration the reaction, if I may borrow from the chemist, of one species or group of species on another. The most severe competitor in the struggle for existence that any given species can have is another species of similar organisation performing a similar function in the economy of nature. This principle, notwithstanding some apparent exceptions, is probably universally true. The slightest advantage tells, and the species wanting it is driven back step by step to its original home or local centre of dispersion.

Let us apply this principle to the voles. We have seen that in probably early Pliocene times the north-west of Europe was colonised by a southern group, *Mimomys*, retaining some very primitive features. This group was, so far as we know, the sole representative of the voles living here until we arrive at the stage represented by the Upper Freshwater Bed of West Runton. Towards the end of the Pliocene period new colonists, *Evotomys*, *Pitymys*, represented by several species, and *Microtus*, including the *nivalis* group, arrived, also coming from the south. The date at which *Pitymys* died out in this country has yet to be ascertained. *Mimomys* and *Evotomys* certainly managed to survive here until the time represented by the High Terrace of the Thames. It may also be presumed that some of the forms of true *Microtus*, including the *nivalis* group, similarly survived, for although we have not found their remains in the very few known repositories of the High Terrace fauna, yet we know that the *nivalis* group was abundantly represented in Britain at a still later period, viz., that of the Middle Terrace. Now until this later stage is reached we have no evidence at all of the existence of any group of vole in Britain other than those mentioned above. In the Middle Terrace deposits we meet with the first evidence of the arrival of the Siberian voles. As on the Continent so here, they appear to have swarmed in rapidly. Instead of the two or three species which at this time remained to us as the wreck of the Pliocene microtine fauna, we received perhaps a dozen new forms. This in itself must have considerably increased the severity of the struggle for existence, a struggle which had been previously keen enough, for the Siberian forms on their arrival were confronted, apparently, only by the *nivalis* group, then at its zenith in point of range and variety, and an old and weak member of the *Evotomys* genus.

The outcome of this invasion was that the new-comers completely supplanted the old southern forms. This is one of my reasons for regarding the Ightham Fissure deposit as of late Pleistocene age, for examining the microtine element of its fauna we find no trace of either the *nivalis* group or the older form of *Evotomys*. They have entirely died out, and in their place we find a rich assemblage of the later immigrants. But with the extermination of the British *nivalis* group the reaction of one species on another did not cease. *Arvicola amphibius* alone did not have to strive hard to maintain its position, for it had no rival in function—it had taken the place of the long vanished *Mimomys*, and there was no other microtine to dispute possession. Of the numerous species of true *Microtus* (of which we have still a very imperfect knowledge) and the Lemmings which came in with the Siberian migration, *M. agrestis* alone has managed to survive to our days as a British resident, and *Evotomys glareolus*, so far as England is concerned, has completely ousted its northern rival *E. rutilus*, which I believe to be represented with it in the Ightham Fissure.

Much the same sort of history can be read from the Continental deposits with this difference, that as we proceed eastwards and southwards the less decisive becomes the result of the struggle. This is what we should expect since we are proceeding towards the centres of dispersion, and so we are really overtaking the vanquished forms in the course of their retreat.

The last and most difficult question with which we have to deal is one that may really concern the origin of Alpine and Arctic faunas. The key to the solution of the problem of why the *nivalis* group chose to inhabit the Alpine peaks and should now show such an extraordinary love for the snow line lies, in my opinion, in the geological history of the group. We have seen how this group spread westwards from its original home in the south-east, reaching North-western Europe in late Pliocene times, and how it formerly extended northwards across the plains from the Alps and Pyrenees to the southern and south-western shores of the Pleistocene Sea of Europe. I submit that it is established as a fact that at the time of this great Pleistocene extension of the group the climate was as mild as at present, and probably even more equable, owing to the different distribution of land and water which then obtained. It follows, therefore, that the *nivalis* group is primarily one with a temperate habitat, and consequently its present peculiar Alpine habitat must be regarded as a subsequently acquired attribute.

We have also seen that the *nivalis* group was exterminated in Britain and the plains of Central Europe by the competition of the rival groups of voles which came from the north and east, and that to-day the group has made a last stand in the mountains, where for the moment it appears to be secure enough. On the lower slopes of these mountain regions it might possibly hold its own against the newcomers, and in summer doubtless the conditions of existence would be congenial to the species. But the severe and early frosts of the lower mountain slopes would hardly fail to be detrimental to such a mammal. It would learn from experience that security from the frost could only be had from an early covering of snow, and consequently it would eventually colonise the summits where the snow-fall is early and remains unmelted for nine or ten months in the year. This view of the case is, in my opinion, borne out by a perusal of Blasius's graphic description[*] of the habits of the species and by examining its known vertical range. Briefly put, these facts go to show that the protection from the frost afforded by the snow is necessary to the prosperity of the species in its present elevated home. The conclusion I would draw, therefore, is a paradox, viz, that *M. nivalis* seeks the eternal snows for warmth, and the principle which has been urged here will, I believe, be found to apply to a great number of other mammals which to-day are confined to Arctic and Alpine regions, but which, nevertheless, had formerly a wide range throughout temperate Europe, and that it applies to many members of the Alpine and Arctic flora has been often demonstrated.[*]

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[*] Blasius, *Säugethiere Deutschlands*, 1857, p. 364. As this book is not one of the most accessible in England, it may be as well to quote the paragraph. He says: "Es ist mir kein Beispiel bekannt, dass sie in den Alpen regelmässig unter 3,000 Fuss Meereshöhe gefunden wäre. Auch bei 4,000 Fuss scheint sie in der Regel noch nicht häufig vorzukommen. Von hieraus aber findet man sie in allen Höhen bis zu den letzten Grenzpunkten der Vegetation. In der Nähe der Schneegrenze erscheint sie am häufigsten. Aber sogar über die Schneegrenze geht sie hinaus und bewohnt noch die kleinsten Vegetationsinseln, die mit den kümmerlichsten Alpenpflanzen spärlich bewachsenen Blössen auf der Südseite der hohen Alpenspitzen, mitten zwischen ewigen Schneefeldern, wo die warmen Sonnenstrahlen oft kaum zwei bis drei Monate lang die wöchentlich sich erneuenden Schneedecken überwinden, und die Erde auf wenige Schritte hin frei legen können. In dieser grossartigen Gebirgseinsamkeit verlebt sie aber nicht bloss einen schönen kurzen Alpensommer; sondern unter einer unverwüstlichen Schneedecke begraben einen neun bis zehn Monate langen harten Alpenwinter. Denn sie wandert nicht, obwohl sie sich im Winter Röhren unter dem Schnee anlegt, um Pflanzenwurzeln zu finden, wenn die gesammelten Wintervorräthe nicht ausreichen. Kein anderes Säugethier begleitet die Schneemaus dauernd über die Welt des Lebendigen hinaus bis zu diesen luftigen starren Alpenhöhen; nur einzeln folgt vorübergehend, als unerbittlicher Feind, ein Wiesel oder Hermelin ihren Spuren."

The laws which I have endeavoured to illustrate in these conclusions have, of course, long been known, but curiously they have often been overlooked when dealing with the fossil mammalia. A more general recognition of such principles will lead, in my humble opinion, to the adoption of far sounder and safer views with regard to Pleistocene history than many of those put forward in the past, will do away with the necessity of invoking vast changes in climate to account for the differences existing between the past and present distribution of animals and plants, and may, moreover, have a not unimportant bearing on that nightmare—the extreme Glacial theory.

In conclusion, I have to express my best thanks to Dr. C. I. Forsyth Major, F.Z.S., for the very generous way in which he helped me through my difficulties, to Dr. C. W. Andrews, F.R.S., Dr. Frank Corner, F.G.S., Dr. F. L. Kitchen, F.G.S., Professor S. H. Reynolds, M.A., F.G.S., and Mr. B. B. Woodward, F.G.S., for many acts of kindness. Lastly, I wish to thank Mr. E. T. Newton, F.R.S., for the kindness which I have so often experienced from him. To him we are all indebted as the pioneer of this branch of palæontology in this country, and to his efforts we owe, primarily, the preservation of the material necessary to these researches.

P.S.—Since correcting the proofs of this paper I have had an opportunity of glancing through Dr. Scharff's new book, "European Animals." Dr. Scharff, I think, comes to much the same conclusion as I do, viz., that the Alpine habitat is a secondary one, and I would refer the reader to pp. 54 and 56, and Chapters vii, viii and ix.

EXPLANATION OF PLATE I.

In the figures the black line represents the enamel as seen on the triturating surface of the molar crown, the broken or thin line in the anterior loop represents the region where the enamel is absent, and the shaded areas show the extent of the cement in the valleys of the tooth. The drawings are enlarged to nearly 12 diameters, and were made with an Abbé Camera-lucida.

Fig. 1.—*Microtus nivalis* (recent), Monte Cimone, Modenese Apennines. Anterior mandibular molars, left side; 1 a., *m.*^{2} left side. (In collection of Dr. Forsyth Major.)

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[*] Scharff, "History of European Fauna," pp. 78, 79, 161–164, and Bulman, *Natural Science*, vol. iii, 1893.

Fig. 2.—*M. nivalis* (recent), summit of Monte Cimone, *m.*$_1$ left side ; 2 a, *m.*^{2} right side. (In collection of Dr. Forsyth Major.)

Fig. 3.—*M. nivalis* (recent), Monte Vecchio. Apennines of Reggio—Emilia left *m.*$_1$ (In collection of Dr. Forsyth Major.)

Fig. 4.—*M. nivalis* (recent ♂), Boscolungo, Pistojese Apennines, left *m.*$_1$. (In collection of Dr. Forsyth Major.)

Fig. 5.—*M. nivalis*, Pleistocene, Gray's Thurrock, right *m.*$_1$.

Fig. 6.—*M. nivalis*, Pleistocene, Crayford, right *m.*$_1$. (In collection of Mr. G. White.)

Fig. 7.—*M. nivalis*, Pleistocene, Crayford, left *m.*$_1$. (In collection of Mr. G. White.)

Fig. 8.—*M. nivalis*, Pleistocene, Crayford, right *m.*$_1$.

Fig. 9.—*M. nivalis*, Pleistocene, Crayford, right *m.*$_1$. (In collection of Mr. G. White.)

Fig. 10.—*M. nivalis*, Pleistocene, Crayford, right *m.*$_1$. (In collection of Mr. A. S. Kennard.)

Fig. 11.—*M. nivalis*, Pleistocene, Crayford. The anterior molars of an imperfect right ramus in the collection of Mr. G. White.

Fig. 12.—*M. nivalis*, Pleistocene, Crayford. The *m.*$_1$ of a right ramus. (Kennard collection, Museum of Practical Geology, No. 6018.)

Fig. 13.—*M. nivalis*, Pleistocene, Crayford, right *m.*$_1$. (In collection of Mr. A. S. Kennard.)

Fig. 14.—*M. nivalis*, Pleistocene, Crayford. The *m.*$_1$ of an imperfect right ramus in collection of Mr. G. White.

Fig. 15.—*Microtus*, a species of the *nivalis* group. Pleistocene, Wickham. The *m.*$_1$ of an imperfect right ramus.* (Spurrell collection, Museum of Practical Geology (No. 5649.)

Fig. 16.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of an imperfect right ramus in collection of Dr. H. C. Male.

Fig. 17.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male †

Fig. 18.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male.

Fig. 19.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male.

Fig. 20.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male.

Fig. 21.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a left ramus in collection of Dr. Male.

Fig. 22.—*M. nivalis*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male.

Fig. 23.—*Microtus*, a species of the *nivalis* group, Clevedon Cave. The *m.*$_1$ of an imperfect left ramus in collection of Dr. Male.

Fig. 24.—*M. malei*, n sp., Clevedon Cave. The *m.*$_1$ of a right ramus collected by Dr. Male.

Fig. 25.—*M. malei*, Clevedon Cave. The *m.*$_1$ of a left ramus collected by Dr. Male.

Fig. 26.—*M. malei*, Clevedon Cave. The *m.*$_1$ of a left ramus collected by Dr. Male.

Fig. 27.—*M. malei*, Clevedon Cave. The *m.*$_1$ of a right ramus in collection of Dr. Male.

Fig. 28.—*Microtus*, sp., Clevedon Cave The *m.*$_1$ of a left ramus in collection of Dr. Male. Inserted in the Plate by an error.

Fig. 29.—*M. malei* (?), Pleistocene, Crayford. Right *m.*$_1$ in collection of Mr. G. White.

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* The thick enamel of the outer side of the anterior loop is shown as extending a little too far forwards.

† The fourth outer angle is made a little too sharp.

THE IGNEOUS ROCKS OF THE BRISTOL DISTRICT.

By Prof. SIDNEY H. REYNOLDS, M.A., F.G.S.

(Read May 3rd, 1907).

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I. INTRODUCTION.

THOUGH the Bristol district is one in which igneous rocks play a very subordinate part, several very interesting types are met with, belonging to two distinct geological periods, the Carboniferous and the Silurian. The rocks occur in three widely separated parts of the district, and it is a noteworthy fact that in each case after it had long been thought that the rocks were intrusive, further research has proved their contemporaneous character.

As this paper is merely a brief resumé of already-published observations by various authors, it has been thought unnecessary to give full references, or to quote as a rule the authorities for the statements made.

II. THE SILURIAN ROCKS.

A special interest is attached to the Silurian rocks of the Bristol district, from the fact that they are the only ones of that age in Great Britain which are known to include contemporaneous volcanic rocks. They occur in two regions—the Tortworth district, in Gloucestershire, and the Eastern Mendip district, in Somersetshire.

1. The Tortworth District*.

The Silurian rocks come on below the Old Red Sandstone round the northern margin of the Bristol Coalfield, and extend on to the Severn at Tite's Point (Purton passage). It is only, however, in the southern part of the area that the Llandovery and associated igneous rocks occur. The latter form two bands, which can be traced more or less continuously in a north-westerly direction from Charfield Green to the neighbourhood of Woodford Green. Here, however, they disappear, and though the Llandovery rocks can be followed round the margin of the Coalfield for a further distance of about three miles no trace of igneous rocks has been met with. Each igneous band consists of a thick mass of trap or lava of an andesitic or basaltic character and of a thin overlying band of calcareous tuff. The lava, which is often highly amygdaloidal, is exposed at many points; the upper band has been quarried at Charfield Green (Cullimore's quarry) and Avening Green, and the lower band at Damery and at Horsley quarry, Middlemill. Damery quarry is still worked, but all the others have been abandoned for many years.

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* An account of the igneous rocks of this District by Prof. Lloyd Morgan and the author has been published in the *Quarterly Journal* of the Geological Society (Vol. lvii, 1901, pp. 267-284).

The tuffs are only met with at two points—Cullimore's quarry, Charfield Green, where the tuff is seen overlying the upper lava band, and Horsley quarry, Middlemill, where it overlies the lower. At each spot the exposure is unfortunately very bad. At Cullimore's quarry the tuff is dark coloured, and consists of minute ashy particles thickly scattered in a calcareous matrix. Fossils are very plentiful; some twenty species have been met with, the commonest being *Favosites gothlandica*, *Orthis rustica* and *Atrypa reticularis*. At Horsley quarry, Middlemill, the tuff is again calcareous, but bears little superficial resemblance to that at Charfield Green, consisting of a pink or white limestone, with large, highly vesicular lapilli somewhat sparsely distributed through it. The commonest fossils are *Favosites gothlandica*, *Stricklandinia lirata*.

2. THE EASTERN MENDIP DISTRICT.*

While in the Tortworth district the igneous rocks play a subordinate part as compared with the normal sediments of Silurian age, in the Mendips the whole Silurian series is of igneous origin. The rocks occur in the most easterly of the four periclinal upfolds which compose the Mendip chain, and are exposed along a tract about three and a-half miles long, with a maximum width of about a quarter of a mile, which extends from Beacon hill, near Shepton Mallet, on the west, to near Downhead on the east. They are completely surrounded by the Old Red Sandstone, and till recently were regarded as intrusive in that formation. They show three well-marked lithological types: (1) trap or lava, (2) normal tuff, (3) coarse ashy conglomerate.

(1.) *The Trap or Lava.*—This is the prevailing rock, and till the recent opening of several new quarries added to the facilities for observation, was the only one recorded. It is worked in the three large quarries of Moon's-hill, Sunnyhill, and Downhead. It probably forms two large masses—a western mass extending from

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* A full account of these rocks appears in the *Quarterly Journal of the Geological Society*, 1907, vol. lxiii, p. 217.

Beacon hill to Moon's-hill, and an eastern mass extending from Tadhill to Downhead. It shows singularly little variation in character, consisting invariably of pyroxene andesite, both augite and enstatite as a rule being present. The ground mass always plays a predominant part.

(2.) *The normal Tuff.*—A thickness of about one hundred feet is seen in Sunnyhill quarry, where the rock dips with perfect regularity below the lava, and a mass with a thickness of perhaps twenty-five feet occurs apparently interbedded in the lower part of the lava. Evidence of the presence of tuff occurs at a number of points along the southern outcrop of the lava, which appears to be underlain by a continuous band of tuff. The tuffs show a considerable amount of lithological variation, some being mainly formed of fragments having a diameter of a quarter of an inch or more, others consisting only of the finest particles. The particular interest of the tuff lies in the fact that at three points it has yielded Silurian fossils. They were found most abundantly at Tadhill, in the first place in material thrown out by moles and rabbits, but afterwards in a section temporarily exposed by trenching. Some two dozen forms have been recognised, the commonest being *Rhynchonella davidsoni* and *Orthis elegantula,* both of which occur in hundreds. *Phacops downingiæ* and *Lindstrœmia* are also common. At Sunnyhill certain bands in the lower part of the tuff section yielded poorly-preserved fossils, the commonest again being *Rhynchonella davidsoni* and *Orthis elegantula.* Unfortunately, at neither locality is the series of fossils sufficient to determine with certainty the exact horizon in the Silurian series, but the probability is that the beds are of Llandovery age.

(3.) *The coarse ashy Conglomerate.*—This, the most remarkable rock of the district, occurs in two areas which alternate with those of the trap and normal tuff. One area lies on the slopes of Beacon hill at the extreme western end of the district, the other lies between the Moon's-hill and Tadhill masses of trap. In no part of the district is the relation of the coarse ashy conglomerate to any of the other rocks clearly seen. In the western or Beacon hill area the coarse ashy conglomerate was originally exposed at the Rifle butts on the slopes of Beacon hill, and a number of trenches have now shown that the material is widely distributed in the neighbourhood. In the eastern area the rock is finely exposed in a quarry opened during 1905 on the hill top a quarter of a mile to the east of Moon's-hill quarry. The coarse ashy conglomerate is also seen *in situ* at a little pond near the fossil locality at Tadhill. In all these places the rock consists in the main of well-rounded blocks of the local trap embedded in a typical tuff matrix, exactly similar to the normal fine tuffs of the district, except for the greater abundance of non-igneous matter in the form of quartz grains and pieces of grit. The blocks attain a length of eighteen inches, and though the great majority are thoroughly well rounded, some are subangular. The deposit shows little or no sign of stratification, and passes at one point into a mass of fine-grained tuff devoid of blocks.

As regards the nature of the coarse ashy conglomerate the two most probable views are either (*a*) that it is an aqueous deposit of the same general age as the associated trap and normal tuff, or (*b*) that it marks the position of the necks from which the trap and normal tuff were ejected.

The former of these two alternative views derives its chief support from the remarkably rounded character of the great majority of the blocks, and if correct would imply that after the submarine deposition of the normal tuff and outpouring of the trap, the surface of the trap was raised sufficiently to bring it within reach of wave action, that it was then partly broken up, and that the great majority of the resulting blocks, after being rolled about and waterworn, were embedded in a matrix of tuff due to a fresh discharge of ashy material of a nature similar to that which had been ejected previous to the outpouring of the trap. The almost complete absence of any sign of stratification in the coarse ashy conglomerate tells against this view. The latter view, according to which the coarse ashy conglomerate represents two volcanic necks, is perhaps the more probable of the two, and is supported by the almost complete absence of stratification in the deposit, and by its occurrence in two well-marked and isolated regions, one at the extreme western end of the area and the other between the two large trap masses of Downhead—Tadhill and Moon's-hill. The rounded character of the blocks would on this hypothesis be due to mutual friction either in the throat of the volcano or perhaps partially in the air.

III. THE CARBONIFEROUS ROCKS*.

Igneous rocks occur associated with the Carboniferous series of Northern Somerset at the following places: Middle Hope or Swallow Cliff, near Woodspring Priory; Spring Cove and Milton hill, both near Weston-super-Mare; Goblin Combe, near Wrington, Uphill, and near Cadbury Camp, North-east of Tickenham. At Middle Hope, Spring Cove, Milton hill, and Goblin Combe the trap rocks are associated with a series of tuffs, and their contemporanecus character is clear; at Uphill and near Cadbury Camp only trap rocks occur, and their contemporaneous character is a matter of inference rather than proof. It is an interesting fact that the igneous series does not in every case occur at the same stratigraphical level in the Carboniferous limestone; at Spring Cove and on Milton hill, where the development is a continuation of that of Spring Cove, the series occurs low down in the Syringothyris Zone (C) of Dr. Vaughan's notation. At the remaining four localities—Middle Hope, Goblin Combe, Uphill, and Cadbury Camp—it occurs on horizon γ., *i.e.*, some 200 to 250 feet lower in the series. In no case does the igneous series attain a greater thickness than about 100 feet, nor does the evidence point to the occurrence of volcanic action on a large scale.

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* Geikie and Strahan, "Summary of Progress of Geol. Survey for 1898," pp. 104-111; Lloyd Morgan and Reynolds, *Quart. Journ. Geol. Soc.* vol. lx, (1904), pp. 137-157, and *Brist. Nat. Soc. Proc.*, new series, vol. x, part iii, 1904 (issued for 1903), pp. 188-212.

As regards the petrography of the rocks they are always definitely basaltic in character, *i.e.*, rather more basic than the Silurian rocks of Tortworth and the Eastern Mendips. The tuffs, too, which are highly calcareous, are also basaltic. They vary in character from tuffs, in which the calcareous matter merely plays the part of a matrix uniting the ashy particles, to limestones in which the ashy particles are only thinly scattered.

Some details concerning the several sections may now be given.

1. MIDDLE HOPE OR SWALLOW CLIFF, NEAR WOODSPRING PRIORY.

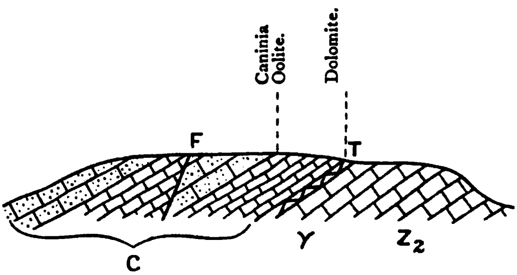
This locality includes a series of four sections of the igneous series, exposed along the northern shore of Swallow cliff, the most westerly of the four (No. 1) being the most complete and interesting of all the sections of Carboniferous volcanic rocks in the district. The section is as follows:

		ft.
12.	Massive limestone (horizon C), with large lapilli in the lower 7 or 8 feet to top of cliff	
11.	Reddish limestone	6
10.	Green tuff	9
9.	Ashy limestone	6
8.	Basalt, much weathered and often highly amygdaloidal	12-14
7.	Green tuff	12
6.	Limestone, full of *Zaphrentis* and other fossils	15
5.	Reddish limestone	6
4.	Tuff	about 12
3.	Limestone with fossils	3
2.	Tuff	about 12
1.	Cherty and crinoidal limestone to base of section	
	Thickness of igneous series	about 100

The remaining three sections all agree in the fact that no lava occurs, the igneous series consisting solely of tuffs. Two of the sections (Nos. 2 and 3) lie at a distance of about three-quarters of a mile to the east of the principal section, and the third (No. 4) near St. Thomas' Head, about half-a-mile still farther to the east. The occurrence of these sections is due to small faults which shift the outcrop to the north. In Section No. 2 the igneous series is about 95 feet thick, and in Section No. 3 about 80 feet thick. They agree in the fact that several limestone bands, which in Section No. 1 separate several of the tuff bands, have disappeared, so that the tuffs have run together, and some bands attain a thickness of about 25 feet. The fourth and last section shows a much attenuated representative of the volcanic series, only some 4 feet of ash and ashy limestone being exposed.

2. Spring Cove, near Weston-super-Mare.

While at Middle Hope the importance of the lava is subordinate to that of the ash; at Spring Cove the reverse is the case, the lava predominating. The principal member of the igneous series is a mass of basalt, having a thickness of about 40 feet and a length of about 150 yards is exposed. It has been described in detail by Prof. W. S. Boulton, on whose paper* the following account is based. It is not a simple basalt flow. The seaward portion is a compact, red, slightly amygdaloidal olivine basalt, with occasional lumps of limestone. Then, a little more than half-way from the low-water end, it changes in character and becomes a very coarse tuff or agglomerate with lenticular masses of slaggy basalt 5 to 6 feet long, and limestone masses of still larger size. This continues for about 20 or 30 yards, when the rock once more becomes a basalt, very amygdaloidal and often variolitic, with pillow structure, large included limestone masses and some tuff. With regard to the middle portion Prof. Boulton considers that "it probably represents a torrent of agglomeratic material that flowed down a slope on the surface of an already-extruded bed of lava, carrying in among the finer lapilli larger, irregular, and plastic masses of scoriaceous basalt-lava of the nature of bombs, together with lumps and fragments of limestone, which from their form and broken character suggest that they were ejected from the vent with the basaltic material." The limestone overlying the basalt contains disseminated ashy particles up to a height of at least 8 feet from the base.



C.—*Syringothyris* Zone.
γ.—Horizon γ, *i.e.* the top of the *Zaphrentis* Zone
Z_2.—Zaphrentis Zone (Cornucopiæ Subzone).
F—Fault. T—Tuff.

FIG 1.—SKETCH SECTION ACROSS THE MIDDLE HOPE PROMONTORY.—*T. F. Sibly.*

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* *Quart. Journ. Geol. Soc.*, vol. lx (1904), pp. 158-169.

3. MILTON HILL, WESTON-SUPER-MARE.

No exposures of igneous rock are now to be seen on Milton hill, but excavations made by Mr. S. G. Perceval and others have proved the existence of lava and ash extending as far to the east as Kewstoke steps.

4. GOBLIN COMBE, NEAR WRINGTON.

Two isolated exposures of volcanic rock occur in this locality, the more westerly about one-third of a mile to the south of Warren House, the other about half-a-mile south-east of the house. At both these spots lava (olivine basalt), as well as tuff, is met with, the lava probably underlying the tuff, but while in the more westerly locality lava occurs *in situ*, in the more easterly it is known only in the form of blocks sparingly scattered over the surface of the fields. The olivine in each case is represented by pseudomorphs, in carbonate in the case of the more westerly exposure, in serpentine in the case of the more easterly. A thickness of about 13½ feet of tuff is exposed in the more easterly section, and at both it is highly calcareous in character, and frequently contains oolitic grains.

5. UPHILL.

Amygdaloidal basalt is exposed in an old quarry on the western side of the railway cutting about 200 yards north of Uphill station, but its relations to the surrounding limestone are not clearly seen.

6. NEAR CADBURY CAMP, NORTH-EAST OF TICKENHAM.

The only evidence now available for the existence of igneous rocks in this locality is in the form of fragments thrown out from rabbit burrows.

ON THE CARBONIFEROUS LIMESTONE (AVONIAN) OF BURRINGTON COMBE AND CHEDDAR.

By T. F. SIBLY, B.Sc., F.G.S.

(Read May 3rd, 1907).

I.—THE BURRINGTON COMBE SECTION.

THIS section, which is by far the most extensive in the Mendips, exhibits an unbroken succession extending from the base of the Avonian up to the basal portion of the *Dibunophyllum*-Zone. The total thickness of Avonian rocks included in the section is about 2,600 feet, of which about 80 feet belong to the *Dibunophyllum*-Zone. The corresponding part of the Avon section has a thickness of about 2,000 feet, the difference being due to a great expansion of the *Zaphrentis*- and *Syringothyris*-Zones in the Mendip area.

The upward succession is from south to north. At the southern end a gradual passage from the O.R.S. up into the Avonian is seen. Duplicate sections of the lowest portion of the series, comprising K and a part of Z, are afforded by two ravines which, furrowing the lower slopes of Blackdown, open into the upper part of Burrington Combe. The remainder of the series is exposed in the Combe itself. At the northern end the section is terminated by the outcrop of the Dolomitic Conglomerate.

The base of the *Dibunophyllum*-Zone is exposed in a small quarry at the mouth of the Combe, on the eastern side. The beds contain a characteristic assemblage of D_1 fossils. The *Seminula*-Zone extends from this quarry to Plumley's Den, a deep cavern on the east side of the Combe. The upper beds of the zone S_2, exposed here and there on the grassy slope, yield characteristic fossils, such as *Seminula ficoides*, *Productus corrugato-hemisphericus* and *Lithostrotion Martini*, and the lower beds S_1 are exposed at a quarry; but the zone as a whole is not well displayed, and the distinctness of S_1 and S_2 is not very easily recognisable. The lithological characters of these two zones do not call for special mention.

The *Syringothyris*-Zone, consisting entirely of massive limestones, is finely displayed. Oolitic limestones are prominent, especially in the upper part, and the lower beds are slightly dolomitic. The typical development of this zone, consisting of an unbroken series of fossiliferous limestones, exhibited here, prevails throughout the Mendip area, and forms a marked contrast with the abnormal development found in the Avon section. The zonal

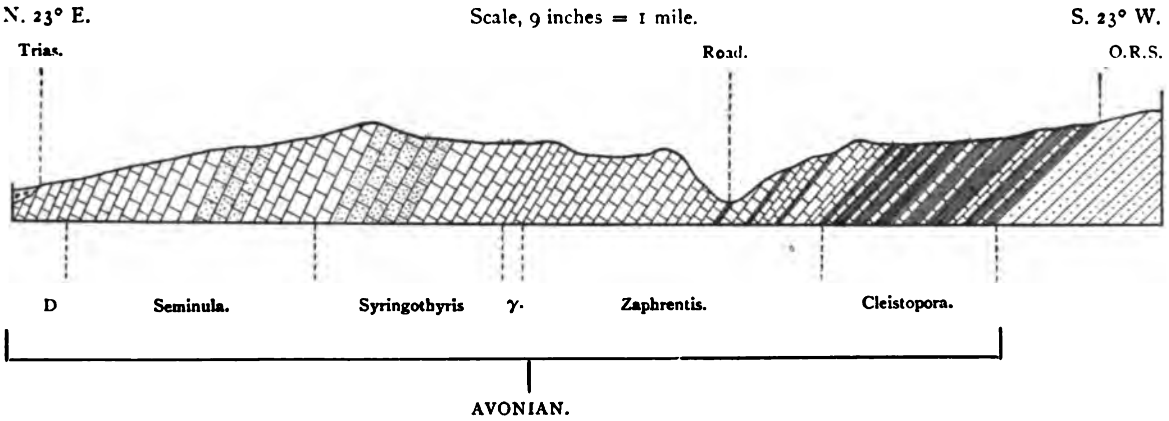

FIG 2.—THE BURRINGTON SECTION.—*T. F. Sibly.*

fauna, which is poorly represented in the Avon section, is here typically developed. In the upper beds, between Plumley's Den and the cave, the common occurrence of *Cyathophyllum* ϕ is noticeable. In the lower part of the zone, at the cave and farther up the Combe, characteristic fossils, such as *Syringothyris cuspidata* and *Michelinia* cf. *megastoma*, can always be found. The lowest beds of the zone, just above Horizon γ, yield *Schizophoria resupinata*, large specimens of *Orthothetes*, and a very large papilionaceous *Chonetes*.

The great thickness of the *Zaphrentis*-Zone forms a prominent feature of the Mendip sequence, and is well seen in this section.

Horizon γ is exceptionally well displayed, and affords a good collecting ground for both corals and brachiopods. The great abundance of *Caninia cylindrica*, in association with *Zaphrentis* aff. *Phillipsi* and *Z.* aff. *cornucopiæ*, is immediately noticeable.

Up to a point lying about 200 yards beyond the outcrop of Horizon γ the Combe has followed a direction not far removed from the line of dip. At this point, however, the gorge bends sharply eastwards, and afterwards runs approximately along the line of strike. The massive limestones in Z_2 form the main part of a magnificent escarpment on the north side of the road. The fossils of this sub-zone can be collected from the heaps of débris at the foot of the escarpment. The common occurrence of *Amplexus* cf. *coralloides*, *Michelinia* cf. *favosa* and *Caninia cylindrica* is noticeable. Chert, in nodular and lenticular masses, is abundantly developed in the beds of this zone, especially in Z_2, The fossils of Z_1 can be collected on the slopes on the south side of the road. *Spirifer* aff. *clathratus* and *Chonetes* cf. *hardrensis* in great abundance, and all their usual associates, can be found. Horizon β is not exposed.

The stream-sections in both of the tributary ravines afford exposures of the *Cleistopora*-Zone, but neither of these sections is easily accessible throughout the whole extent of the zone. The eastern ravine affords the better section. The zone exhibits its usual characters. K_2 and K_1 can be examined only by working up the bed of the stream, but the *Modiola*-phase (K_m) is more readily accessible. The shales of the *Modiola*-phase yield Ostracods in abundance, and Modioliform lamellibranchs.

II.—THE CHEDDAR SECTION.

The Cheddar Gorge affords a section extending from the Upper *Syringothyris*-Zone into the Upper *Dibunophyllum*-Zone.

C_2 is not so well exposed as at Burrington. The uppermost beds contain *Cyathophyllum* ϕ commonly.

The importance of the section lies in the fine exposure of S_1. In this respect the Cheddar section supplies one of the chief deficiencies of the Burrington section. This sub-zone exhibits the typical faunal characteristics of S_1 as developed in the Bristol area, with the sole exception that *Caninia cylindrica*, mut.S_1, is apparently nowhere common. *Lithostrotion Martini* and *Seminula ficoides* occur abundantly at various levels. The upper beds of the sub-zone, very well exposed in a large quarry in the gorge, contain *Productus* θ in great abundance; *Productus semi-reticulatus*, mut.S_1, occurs commonly at this level, and *Athyris* cf. *expansa*, a fossil characteristic of C_2 and S_1 in the Mendips, is common.

A highly interesting feature of S_1 in the Cheddar section is the occurrence of a special fauna at the base. The characteristic fossils—*Carcinophyllum mendipense*, *Camarophoria isorhyncha* and *Spirifer* cf. *furcatus*—are associated with *Athyris* cf. *glabristria* and *Lithostrotion Martini*. This fauna is apparently very localised in its distribution. It is equally well-developed at the same horizon at Weston-super-Mare; but no similar development has yet been recorded in any other part of the South-western Province, and no trace of it has been discovered at Burrington. The horizon is well exposed at Cheddar, and fossils can always be collected.

S_2 is not so well exposed for examination, but the whole sub-zone is included in the section in the lower part of the gorge. Bands containing an abundance of *Lithostrotion Martini* or *Seminula ficoides* can be seen in places.

D_1 is poorly exposed in a disused quarry at the entrance to the gorge, some distance south of the Cliff Hotel.

NOTE ON THE CORAL ZONES OF THE AVONIAN (LOWER CARBONIFEROUS).

BY ARTHUR VAUGHAN, B.A., D.Sc., F.G.S.

(Read May 3rd, 1907).

RECOGNISING how limited is the time which the Geologists' Association can spare, during their visit, for the study of the faunal succession in the Avonian rocks of the Bristol area, I have prepared the following brief statement of the main results of recent work; only the broadest outline is here sketched and details are purposely omitted in order that attention may not be diverted from the essential facts.

The Corals and Brachiopods are the only groups which have, as yet, been specially studied in regard to their succession and mutation during Avonian time. Of these two groups, the corals are of the greater service in that their rate of variation with time is more considerable, and also in the fact that mere fragments are readily determined by horizontal sectioning. The Brachiopod succession, although very valuable as confirming the sub-divisions based upon the coral sequence, cannot be adequately treated within the limits of a necessarily short note.

THE CORAL SUCCESSION.

The Avonian comprehends almost the complete history of Carboniferous Corals in the British Isles. In the lowest beds corals are rare, in the main portion they occur in profusion, and extremely few forms transgress the upper limit.

In the lowest, or *Cleistopora*-zone (K), true Avonian Corals are notably absent. A species of *Cleistopora*, closely allied to *Cleistopora geometrica* of the Devonian, forms a valuable index to the zone, although it is rare except at one or two levels.

With the *Zaphrentis*-zone (Z) we encounter, in *Zaphrentis* aff. *Phillipsi*, the earliest representative of the true Avonian Coral-fauna. This simple *Zaphrentis* comes in at the base of Z, increases to a maximum in the upper part of the zone, and rapidly declines in number in the succeeding *Syringothyris*-zone.

The uppermost part of the *Zaphrentis*-zone witnesses the acme of *Zaphrentis*. In Belgium, a large number of species of this genus have been recorded from this level; but in the South-West Province all the Zaphrentes are mainly referable to two species, namely *Zaphrentis* aff. *Phillipsi* and *Z.* aff. *cornucopiæ*. The latter is a specialised and easily-recognised form which especially characterises the upper part of Z (Z_2).

Within the *Syringothyris*-zone (C), all the great groups which become dominant factors of the Coral-fauna in higher zones are already represented by progenitors of simple Zaphrentoid type, which clearly exhibit the source from which they were derived. [The same abnormal activity of variation is exhibited with equal clearness by the Brachiopods of the *Syringothyris*-zone, and it is a suggestive fact that this period of exceptional faunal change synchronised with the epoch of main earth-movement during Avonian time]. The earliest coral group to succeed *Zaphrentis*, as the dominant factor in the Coral-fauna, was that of the Campophyllids. The lower part of the C zone (C_1) is characterised by the abundance of *Caninia*, the most zaphrentoid of all the Campophyllids. Upper *Syringothyris*-time (C_2) witnesses the evolution of the *Cyathophylla* from the Campophyllids and the parallel-development of the Cyathophylloid-*Campophylla*, these two groups dominating C_2. (N.B.—The *Syringothyris*-zone is the uppermost zone of the Tournaisian or Lower Avonian).

The *Seminula*-zone (S), named from the extreme abundance of *Seminula ficoides* throughout the whole extent of the zone, forms the base of the Viséan or Upper Avonian. It is distinguished by the enormous abundance of Lithostrotion, both dendroid (*Siphonodendron*) and massive (*Nematophyllum*). This prolific genus is derived from a Cyathophylloid-Campophyllid stock, and the earliest forms are practically devoid of columella.

In the lower part of the zone (S_1), Cyathophylloid-*Campophylla* are still common, whereas, in the upper part (S_2), *Carcinophyllum* (a Campophylloid-Clisiophyllid) becomes an important factor in the fauna and heralds the incoming of the more typical Clisiophyllids.

The *Dibunophyllum*-zone (D) marks the acme of coral development and is essentially characterised by the establishment and dominance of the true Clisiophyllids, which increase in structural complexity as they pass upwards through the zone.

The lowest sub-zone (D_1) contains simple structural types such as *Dibunophyllum* θ and *Koninckophyllum* θ which exhibit no great advance upon highly developed Lithostrotions, and with these, at the base of the zone, *Carcinophyllum* is still abundantly associated.

The middle sub-zone (D_2) includes more highly specialised forms such as *Dibunophyllum* ψ, and is especially characterised by the abundance of *Lonsdalia*.

The highest sub-zone (D_3) contains no corals in the Bristol area, where it is represented by the Millstone Grit.

Descriptions and figures of the Coral Genera referred to above will be found in the paper by the Author, *Bristol Nat. Soc. Proc.* (1906), pp. 130-148.

TABULAR RÉSUMÉ TO ILLUSTRATE THE RECOGNITION OF THE AVONIAN ZONES BY THE PRESENCE AND ABSENCE OF PARTICULAR CORAL-GROUPS.

AVONIAN.

	TOURNAISIAN.			**VISÉAN.**	
ZONE.	Cleistopora (K).	Zaphrentis (Z).	Syringothyris (C).	Seminula (S).	Dibunophyllum(D).
CORAL GROUPS PRESENT.	*Cleistopora.*	*Zaphrentis.*	Campophyllids, especially *Caninia.*	*Lithostrotion.* *Carcinophyllum.*	Clisiophyllids, especially *Dibunophyllum.*
CORAL GROUPS ABSENT.	All other groups mentioned in this table.	*Lithostrotion.* *Cyathophyllum.* Clisiophyllids.	*Lithostrotion.* { *Dibunophyllum.* { *Carcinophyllum.*	All Clisiophyllids *except* *Carcinophyllum.*	

The annexed table illustrates the method of recognition of the various Avonian Zones by the presence or absence of particular coral-groups.

The distinction of the sub-zones (in ascending order) is as follows:

- (Z)
  - (Z_1) *Zaph.* aff. *cornucopiæ*, absent.
  - (Z_2) ,, present; *Caninia* at top.
- (C)
  - (C_1) *Zaphrentis*, usually common; *Cyathophyllum*, practically absent.
  - (C_2) First establishment of *Cyathophyllum*; *Zaphrentis* rare.
- (S)
  - (S_1) Cyathophylloid-*Campophylla*, common; *Carcinophyllum mendipense.*
  - (S_2) Cyathophylloid-*Campophylla*, rare; *Carcinophyllum* θ.
- (D)
  - (D_1) *Dibunophyllum* θ, *Koninckophyllum* θ, *Carcinophyllum* θ.
  - (D_2) *Dibunophyllum* ψ, *Lonsdalia.*
  - (D_3) A Zaphrentid phase characterised by *Cyathaxonia rushiana*, *Zaphrentis* aff. *Enniskilleni*, *Amplexi-Zaphrentis.*

The first establishment of *Lithostrotion* marks the start of Viséan or Upper Avonian, and the base of the *Seminula* zone.

The first establishment of *Zaphrentis* marks the base of the *Zaphrentis*-zone.

The first establishment of *Dibunophyllum* marks the base of the *Dibunophyllum*-zone.

N.B.—These three assumptions are purely matters of convention, and introduce a small error representing relative acceleration; this error is, however, practically unimportant in comparison with the zone-interval.

VISIT TO THE BRUCE CASTLE MUSEUM, TOTTENHAM.

SATURDAY, MARCH 9TH, 1907.

Director: THOMAS W. READER, F.G.S.

(*Report by* THE DIRECTOR.)

THE party, numbering twenty-five, assembled at the castle and the Director gave an account of the interesting building now occupied by the museum.

Bruce Castle stands upon the site of a residence of Waltheof, who was Earl of Huntingdon at the time of the Conquest. The earl was beheaded for conspiracy, but his wife, who was a niece of William the Conqueror, was allowed to retain the house and lands. At her decease they passed to her only daughter Maud, who married as her second husband David I., King of Scotland, who became in her right Earl of Huntingdon. At his death the estate passed to his son Henry, and then successively to his grandsons, Malcolm IV. and William the Lion, Kings of Scotland. The last-named conferred it on his brother David, Earl of Huntingdon, whose daughter Isabel was married to Robert Bruce, the father of the competitor for the Scottish crown in the time of Edward I. Edward decided in favour of the counter-claimant Baliol, and Bruce and his son are said to have resided subsequently on their estate at Tottenham, which was named Bruce Castle or Le Bruses. On the rebellion of his more famous grandson Robert Bruce, who thereby became King of Scotland, the manor was forfeited to the crown, and its connection with the Bruces ended.

After passing through several hands the property was given by Henry VIII. to Sir William Compton, Groom of the Bedchamber, and in 1516 the King met his sister Margaret, wife of James IV., King of Scotland, in this house, which had been rebuilt by Sir William Compton more or less in its present style.

Some fifty years later Queen Elizabeth was the guest of Lord Compton at the castle. From the Comptons the castle passed to the Lords Coleraine of the family of Hare, and it was altered to practically its present condition by one of them in the latter part of the 17th century. From them it came to the Townsend family, and was eventually bought by Sir Rowland Hill, of penny postage fame, who turned it into a school, a condition in which it remained until a few years ago.

The party were then conducted over the Museum by Mr. F. J. West, the Borough librarian. He said that when the school was given up it was felt by many in Tottenham that this building, whose history just given by Mr. Reader, showed links with kings, queens, and nobles, ought not to be pulled down and the ground built over, and with the assistance of Mr. Joshua Pedly the property was purchased by the Tottenham Local Board.

Mr. West said that he was desired to express the regrets of the Chairman of the Council (Mr. C. C. Knight, J.P., F.Z.S.), and of the Chairman of the Library and Museum Committee (Mr. W. W. Lewis), that they were prevented by other engagements from being present. He gave a short account of the origin and growth of the Museum, which was formally opened on October 25th, 1906.

The points of chief interest to the party were two separate geological collections, one being that loaned by Mr. H. E. Smedley, F.G.S., and the other a collection made by the late Mr. Penistone, of Stoke Newington, a friend of Ruskin, who, it is said, had interested himself in its formation. This collection was acquired for a nominal sum through the kind offices of Mr. Knight.

The collections were then examined by the members of the party, and it was noted that they contained many specimens of great interest, principally from the Chalk, Oolites, and Lias. Unfortunately, in many cases the localities of the specimen were lost, but as the fossils are arranged and intended to be studied zoologically, and not stratigraphically, this was not of so much importance from the point of view of the student. A number of wax models made by Mr. Smedley were also much admired. These represented most of the large types of extinct reptiles restored according to accepted ideas, such as Ichthyosaurus, Plesiosaurus, Pterodactyl, Diplodocus, and many other of the large Dinosaurs. There were also a series of botanical models made by Mr. Smedley, and two interesting zoological collections, one presented by Mr. Knight, and the other purchased by subscription from Mr. Roberts, formerly of Tottenham, but now of Wanstead.

After the party had examined the building and its contents, the President, in moving a vote of thanks to the Director, to Mr. West, and to the Council and the Library and Museum Committe of Tottenham, referred to the interest that the Association felt in visiting these local museums, the true home of local collections, and he expressed a hope that the public spirit which had animated the Council and those other residents who had been interested in the preservation of this interesting building and the foundation of the Museum, would be appreciated by those for whose use it was intended.

VISIT TO THE BRITISH MUSEUM (NATURAL HISTORY), SOUTH KENSINGTON.

Department of Botany.

SATURDAY, MARCH 16TH, 1907.

Director: JAMES BRITTEN, KNIGHT OF ST. GREGORY, F.L.S.

(*Report by* THE DIRECTOR.)

THE party assembled on the top landing at 2.45 p.m., where they were received by Mr. Britten, who, in the unavoidable absence of Dr. A. B. Rendle, had arranged to give a demonstration.

Mr. Britten explained that the demonstration had been announced under the title of "Some Historical Collections," and he would consequently confine himself to illustrations of the work of Sir Hans Sloane, of Sir Joseph Banks, and of those who assisted them. He remarked that the National Herbarium was of unequalled value in its historical aspect, containing, as it did, so much of the work of the botanists of the seventeenth century, together with collections of an even earlier date included in the great Herbarium of Sir Hans Sloane, which was comprised in 334 folio volumes, of which the first eight were devoted to Sloane's own collection made in Jamaica (1687-89). Besides the plants themselves, these volumes contain the original drawings from which the engravings for the Natural History of Jamaica were prepared; Sloane's own copy of the work, containing his MS. additions and his references to the Herbarium, was also shown. Among the other contents of the Sloane Herbarium exhibited were the collections of James Petiver (1658-1718), Apothecary to the Charterhouse; Leonard Plukenet (1642-1706), containing 8,000 specimens; Mark Catesby, who was in North America from 1712 to 1726; James Cunningham, who collected in China, 1698-1703; Hermann, Oldenland, and other earlier collectors at the Cape; and Kaempfer's plants from Japan.

The collections of Sir Joseph Banks, which were the foundation of the National Herbarium as it now exists—the Sloane volumes having been retained as a separate collection—practically began with the plants collected in Australia, New Zealand, the Pacific Islands, and elsewhere during Cook's First Voyage round the World in 1768-71. In connection with these were shown the volumes of drawings made during the voyage by Sydney Parkinson, elaborated on the return of the expedition by the best botanical artists of the day and engraved for publication at Banks's expense, but never published; a volume of reproductions of the Australian drawings was prepared for publication by Mr. Britten and issued by the Trustees of the Museum a few years back. Some of the various important collections acquired by Banks were also exhibited, including Hermann's Herbarium of Ceylon plants, on which Linnæus based his "Flora Zeylanica"; the Gronovian Herbarium, containing Clayton's Virginian plants, collected in the eighteenth century, on which many of Linnæus's descriptions are based; the herbaria of George Clifford, of whose garden plants Linnæus published an account in his "Hortus Cliffertianus," and Philip Miller, the types of his "Gardeners Dictionary," as well as the plants of Alexander and Patrick Russell, collected in Aleppo toward the end of the eighteenth century; and the important specimens, with the drawings of Father Kamel, who collected in the Philippines at the same period. The collections made by John and George Forster during Cook's Second Voyage (1772-5) in Australia and the Pacific Islands, with the drawings made by the latter, and the Herbarium of Thomas Walter, containing types of his "Flora Caroliniana" were also shown.

In conclusion, Mr. Britten gave a sketch of the work of Daniel Solander and Jonas Dryander, who were successively librarians to Banks, and whose MSS. form an important addition to the Herbarium. Their connection with the publications of the day, such as Aiton's "Hortus Kewensis," was shown, and stress was laid on the fact that they were content to work without any anxiety for publication. This tradition was carried on by the great Robert Brown, the exhibition and explanation of whose admirable Australian collections and manuscripts brought the demonstration to a conclusion.

The demonstration was attended and much appreciated by about thirty members, and a very hearty vote of thanks was accorded Mr. Britten on the motion of the President.

EXCURSION TO EAST WICKHAM.

SATURDAY, MARCH 23RD, 1907.

Director: A. L. LEACH.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR.)

THIS Excursion had been arranged with the object of visiting the chalk-mines below Gregory's brickfield mentioned in the report of the excursion to this locality on April 28th, 1906 (*Proc. Geol. Assoc.*, vol. xix, pp. 341-345), but this was not possible since, contrary to expectation, the chalk-mine has not been opened this winter.

A large part of the chalk raised in 1906 still remains in stock and until it is used up no work will be done in the mine. The proprietor has, however, kindly promised to allow a party to go down as soon as work in the mine is resumed next winter.

All those who had, in compliance with the request in the Circular, notified to the Excursion Secretary their intention of attending the Excursion, duly received notice that the Tertiary and Chalk sections in the East Wickham valley would be visited instead of the mine. A party of 13 met at Plumstead and the excursion of last April was practically repeated.

The sections were in very good order and the weather was all that could be desired for our first field excursion of 1907.

A hearty vote of thanks was accorded to the Director.

EXCURSION TO PLYMOUTH, EASTER, 1907.

Director: W. A. E. USSHER, F.G.S.

Excursion Secretary: G. E. DIBLEY.

(*Report by* THE DIRECTOR.)

THE members assembled at Plymouth on Thursday, March 28th, and took up their quarters at Farley's Hotel.

Friday, March 29th.—Favoured by splendid weather the party, numbering 49, proceeded to the starting place for the Turnchapel steamboats. Whilst waiting for the boat the Director gave a short address on the early readings of the Devonian section. The Devonian limestones were the first member of the series to receive special attention. The Plymouth limestone was described by Hennah in the early part of the nineteenth century and later on Lonsdale assigned to the limestones a position between the Carboniferous and Silurian, as a marine equivalent to the Old Red Sandstone. Sedgwick and Murchison extended this correlation to the pre-carboniferous slates and grits in which the limestones occurred, thus establishing the Devonian System and including in it the Palæozoic rocks which emerged in North and South Devon from beneath the central trough of Culm Measures which they had shown to be the main structure of Devon. Owing to the north and south post-carboniferous contraction, called the Armorican movement, proceeding from the south the axes of the folds were bent northward on either side of the Culm trough. This fact favoured the normal descending succession of the rocks of the

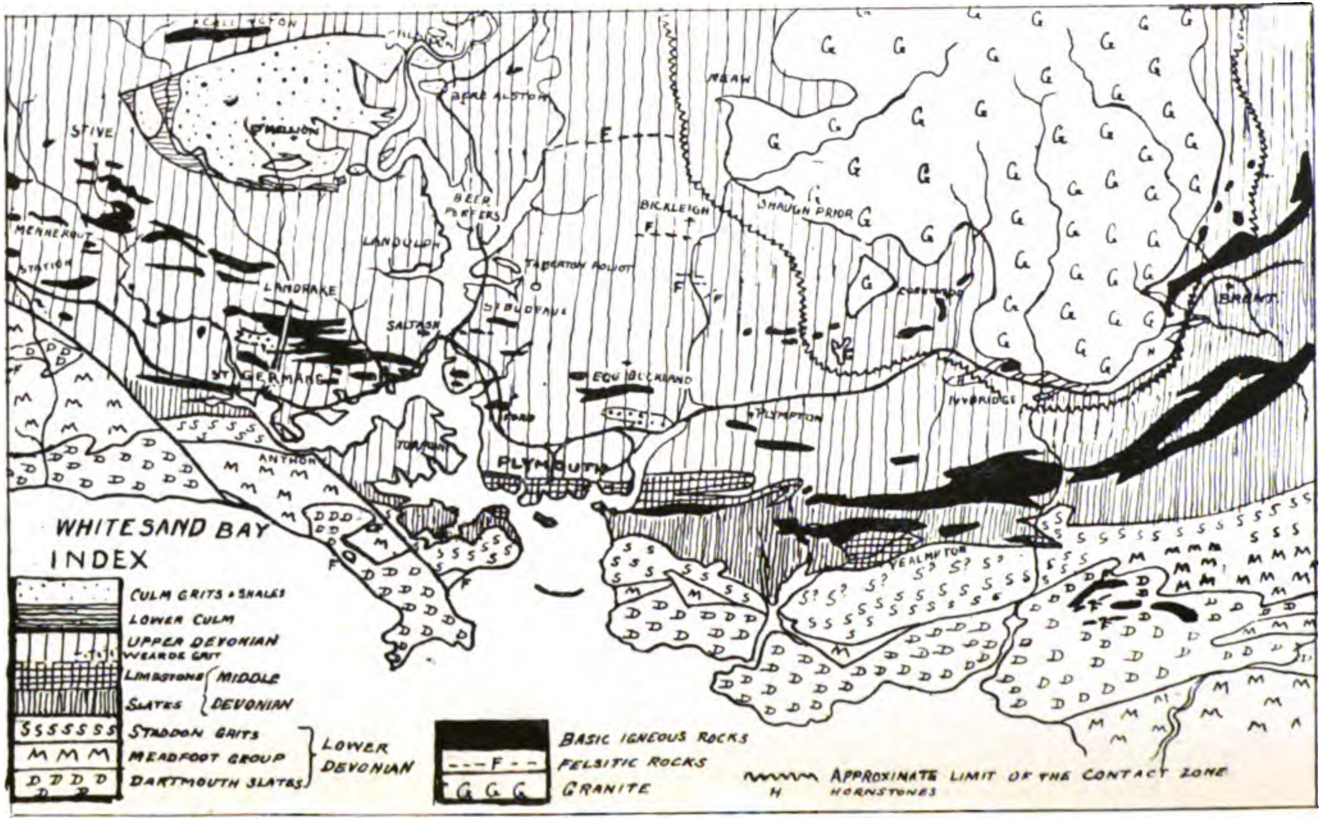

FIG. 3.—GEOLOGICAL MAP OF PLYMOUTH DISTRICT.—*W. A. E. Ussher, F.G.S.*

Scale, 4 miles = 1 inch.

By Permission of the Director of the Geological Survey.

northern outcrop from the Culm Measures northward, which is so well described in De la Beche's Report. But notwithstanding the recognition by Phillips of the Upper beds on the southern margin of the Culm trough at South Petherwin, the oldest Devonian strata in the southern outcrop were placed between the Plymouth limestone and the southern lip of the Culm trough, whilst from the limestone southward Sedgwick and Murchison gave an ascending series up to the metamorphic rocks of Hope Cove. Although this error was no doubt largely due to the prevalent southerly dip of the cleavage planes and of the bedding through overfolding, it is very probable that the more detailed work of De la Beche in Cornwall and of Godwin Austen in South Devon, by introducing fresh sources of confusion, tended to perpetuate it. Pointing to the outcrop of the Lower Devonian rocks on Staddon heights the Director explained that this outcrop throughout South Devon maintains an east and west strike (see Map iii, Fig. 4),* but that on crossing to Cornwall it is shifted northward by a series of north-west and south-east faults, so that it reaches the north coast of Cornwall at Bedruthan steps much farther to the north. This structure inferred by him in 1890 (see Map ii, Fig. 5) † was subsequently proved by detailed mapping to be the Key to the Devonian stratigraphy of Cornwall, and furnished the explanation of the blending of Upper and Lower Devonian rocks, distinct in lithological types and fossil contents, in De la Beche's minor subdivisions, as he had traced the rocks now known to be Upper Devonian westward into the Lower Devonian districts without perceiving the intervening dislocations. Furthermore the variegated Lower Devonian slates of Watergate Bay (the Dartmouth slates), the lowest known division of the Devonian (which would be seen at Andurn Point), were correlated by De la Beche with the purple and green Upper Devonian slates, the series which corresponds to the Cypridinen Schiefer of the Continent and which would be seen at Wivelscombe quarry and in the Ince Castle coast on Saturday's excursion.

Godwin Austen in the Torquay area further complicated the geology by regarding the repetition of the limestones through faults and folds as successive outcrops.

Holl's maps in 1868 (see Map i, Fig. 6),‡ notwithstanding his recognition of inverted folding, shows the lower rocks on the north, "the Lower South Devon group," and the "Upper South Devon group" on the south, of the limestones, with an infold of the lower group. Clearly recognising the obstacle to this view presented by the age assigned to the Petherwin Beds, bolder than his predecessors he endeavoured to explain away the fossil evidence on which it was based.

The preliminary notice for the Long Excursion in 1884 (*Proc.*

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* *Somerset Arch. and Nat. Hist. Soc*, 1901.

† *Trans. Roy. Geol. Soc.*, Cornwall, 1891.

‡ Based on Holl's map in *Quart. Journ. Geol. Soc.*, vol. xxiv, Pl. XVI.

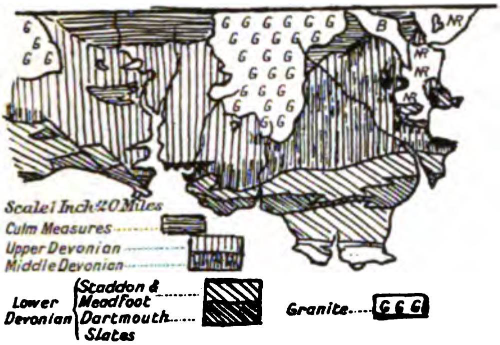

FIG. 4.—MAP III. USSHER (After Survey), 1900.

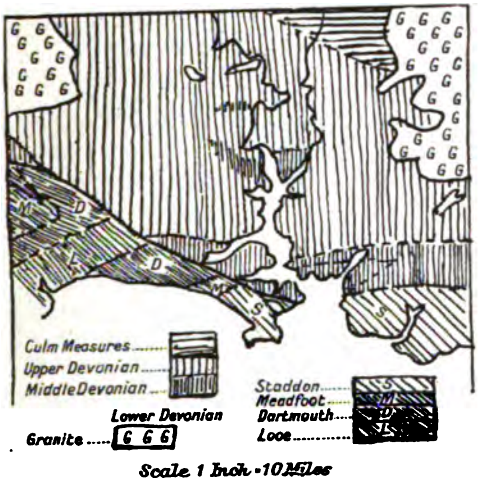

FIG. 5.—MAP II. USSHER (Before Survey), 1890.

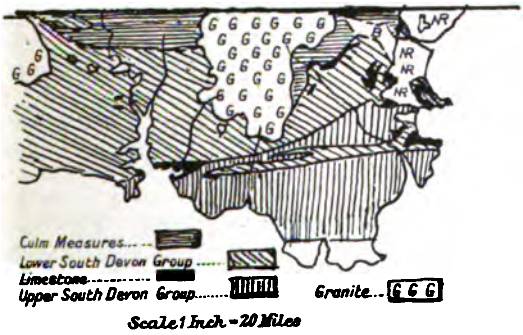

FIG. 6.—MAP I. HOLL'S GROUPING, 1868.

Geol. Assoc., vol. viii, p. 442) proves no advance on earlier ideas. As regards the special study of the rocks and deposits of the area the papers written by the late R. N. Worth are invaluable.

The arrival of the steamer having put an abrupt termination to the discourse the party observed on passing the limestone cliffs of Catdown the comparatively horizontal bedding of the central parts of the limestone mass, which was best enabled to resist the folding.

Landing at Turnchapel in order to traverse the inverted downward succession from the limestone to the Dartmouth slates, a short halt was made to inspect a cutting in the lower (Eifelian) slates of the Middle Devonian near Fort Charles. The Staddon grits were next encountered on their salient outcrop feature. Closer inspection was debarred by the War Department, which had annexed the path, open to the public when the Director was stationed in Plymouth. Consequently a fine section of Staddon grits with several conglomeratic beds in the tabooed ground could not be seen, and a considerable détour involving some scrambling amid furze and brambles had to be made before reaching Bovisand Bay. At Bovisand Bay the Middle Division of the Lower Devonian, the Meadfoot group, succeeds the Staddon grit. In a short walk by the cliff path Andurn Point was reached. The Director here showed the purplish and green Dartmouth slates, with a mass of Diabase. These slates form the low coast of Andurn Point and with interbedded grits extend thence to Westcombe beach, near Ringmore. He had found traces of *Pteraspis* in them near Langdon Court inland, and at Piskey's Cove, near Revelstoke, but not elsewhere in Devon. Faults, well marked by the beach reefs, separate the Dartmouth slates from the lower part of the Meadfoot group, which here resembles them in colour and corresponds to the Taunusien of the Continent. Between the faults a mass of breccia of local fragments under Head or old screes was pointed out, as the outlier of New Red mentioned by Sedgwick and Murchison in their description of this coast.

From the fault proceeding northward to Crownhill Bay calcareous slates associated with hard grits and sandy, decomposed, friable beds full of casts of irrecognisably distorted fossils were seen to be repeated by numerous folds. The Director pointed out the occurence of numerous thin bands of limestone veined and mottled by irregular patches of calcspar, evidently of organic origin and perhaps Monticuliporoid corals. These limestones, he said, were met with in the fine section on the Tregantle coast and at East Looe; they are characteristic of the Looe beds on the coast, and had furnished him with a valuable horizon in correlating the different sections on either side of the Dartmouth slate anticlinals in South Devon and South-east Cornwall. These remarks were punctuated by the discovery on the spot of a recognisable Monticuliporoid coral by Mr. E. T. Newton.

On reaching Crownhill Bay the calcareous rocks were seen to terminate, plunging steeply under a series of grey slates, the junction being complicated by thrust faulting on a small scale. From here to Bovisand Bay the rocks form the upper part of the Meadfoot group and correspond to the Lower Coblencien. In Crownhill Bay single corals of Zaphrentoid character, Crinoids, and other fossils were noticed in the slates. The tide did not permit of rounding the headland between Crownhill and Bovisand Bays, split up by narrow coves in which traces of igneous rocks of Torcross type had been detected.

In Bovisand Bay fine examples of curved and contorted bedding crossed by cleavage planes almost at right angles were noticed. On the north side of Bovisand Bay the highest beds of the Meadfoot group, consisting of slates irregularly associated with thick beds of hard grit, were seen; they are intersected by several small faults which also affect their junction with the red Staddon grits. The section is here overlain by a fine example of Head consisting of red loam with local stones, sometimes presenting a more or less stratified appearance. The Director explained that this Head or old talus was shed from the neighbouring highland on the old beach-platform, during the elevation which succeeded the formation of the raised beaches, and that its antiquity is amply vouched for by the numerous instances, some of which he had figured, on the Devon and Cornish coasts, where stacks of Head are found on fragments of old beach-plane insulated by the sea, in the recent depression which circumscribed and finally overwhelmed the forests on the foreshore.

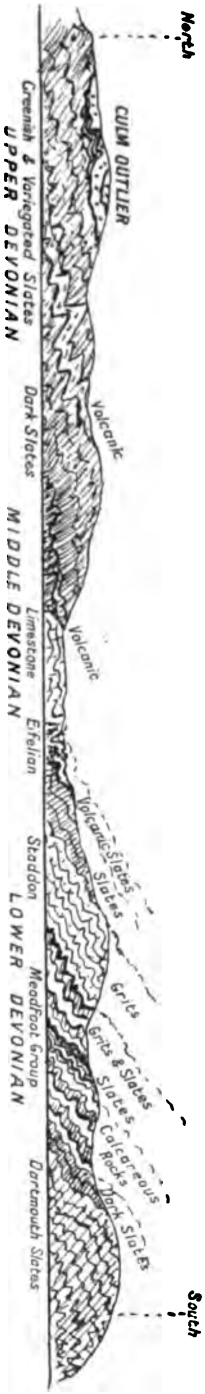

FIG. 7.—DIAGRAMMATIC SECTION OF THE DEVONIAN ROCKS OF THE PLYMOUTH DISTRICT.—*W. A. E. Ussher.*

On the return journey the contorted character of the Staddon grit coast was pointed out, so far as it could be seen looking down from the summit of the cliff not yet annexed by the War Department. Time and crowds of holiday folk did not permit of a close inspection of the lower beds of the Middle Devonian (Eifelien) but some members of the party were shown the associations of slate with beds of limestone and decomposed volcanic rocks which are repeated by folds in the low coast line approaching Mount Batten, where they are infolded with the limestone.

A much-needed tea was provided at the Coastguard Station and after a rest of half-an-hour the party proceeded to Turnchapel, visiting the limestone quarry in Clovelly Bay on the way. Here the limestone is overlain by Schalstein, but whether the junction is natural or inverted there is no means of ascertaining. The Director pointed out the irregular replacement of the limestone by volcanic rocks as a necessary consequence of the irregular extension of volcanic ejectamenta at one time invading and checking the growth of a coral bank, at another time receding and allowing of its advance, and this he considered to have been the case to some extent along the southern margin of the Plymouth reef. The return to Plymouth by steamer, and a walk to the Hotel across the Hoe, brought the proceedings of an enjoyable if somewhat laborious day to an end.

The Strata seen in descending sequence are given in the following table with foreign correlations.

Middle Devonian	Limestone - Slates and Schalsteins	Stringocephalen-Kalk. Schalstein. Eifler-Kalk.
	Slates - - -	Eifelien.
Lower Devonian	Staddon Grits - -	Upper Coblencien.
	Meadfoot Group -	Lower Coblencien. Taunusien.
	Dartmouth Slates -	Gedinien.

In the diagrammatic section (Fig. 7) the relations of the Devonian divisions are shown.

Saturday, March 30th.—On Saturday the party proceeded to North Road Station, where at 9.30 the Assistant Divisional Superintendent of the G.W.R., Mr. Kateley, met them and accompanied them in the Special Rail Motor Cars placed at their disposal by the Company. Owing to the congestion of Easter traffic the Director was informed that it would be impossible to detrain at Defiance Halt to see the Wearde Quay Coast and rejoin the cars at 11.30 a.m., as arranged in the programme, so he decided to proceed direct to Wivelscombe Lake without a stop and to return by the Motor from Defiance Halt at 5.8 p.m.

After leaving the train a short walk across country southward brought the party to the low coast line of the St. Germans Estuary near Ince Castle. The Director pointed out the position of the faulted outcrop of the Lower Devonian rocks on the high ground under Antony Fort on the south and on Earth Hill. This fault is the continuation of that which cuts out the Meadfoot group at Cawsand and here cuts off the Upper Devonian against the Staddon grits. The Upper Devonian rocks of the area consist of purple and green slates passing irregularly downward into grey slates in which the Director had found on this coast traces of the Büdesheim fauna of Germany. The rocks were essentially slates in which bedding was only locally apparent through induration or decomposition of harder calcareous films or through streaks of different tint. The fossils occurred in nodules of brown friable material the residue of limestones, which would be seen in abundance farther on. This type corresponds to the Knollen-Kalk of Germany. Traces of the Büdesheim fauna, consisting of small *Goniatites*, had been found in only one other locality in the Plymouth district, viz., near Warren Point on the Devon shore of the Tamar opposite Landulph promontory.

The purple and green slates contain bivalved Entomostraca or Cyprids, and correspond to the Cypridinen-Schiefer of Germany. Proceeding slowly for about 500 yards to the place where the nodules are most frequent, numerous traces of fossils were found, including *Bactrites* and casts of shells which could not be identified. At the junction of the grey, and purple and green slates Cyprids, resembling the characteristic *Entomis serratostriata* and *E. gyrata* and small *Tentaculites*, were found, but time did not permit of further search for the *Goniatites*. The party then proceeded to Wivelscombe Quarry, where the purple and green slates are well exposed, and there halted for luncheon, many having obtained new milk at a farm in the vicinity. The quarry was being worked; the slates when ground to powder and treated with acids furnish a deep red paint, samples of which were seen.

From Wivelscombe Quarry to Forder the distance is about a mile, and examples of igneous rocks were seen by the way in the cuttings on the new line from Defiance to St. Germans in course of construction.

At Forder a quarry by the creek was inspected. Here a good example of hornblende dolerite or proterobase was seen, and also indurated slates and contemporaneous volcanic rock. Ascending the hill above this quarry the party walked across country, negotiating divers hedges by the way, to the road to Wearde Quay and Defiance Halt. By this road they were shown a quarry in the Wearde grits, a series of evenly-bedded grits or greywackes with bands of shale or mudstone. Descending to the coast they entered the lawn of H.M.S. Defiance, the Guard Ship. Here the Director showed them a quarry in mica diabase overlain by Wearde grits and mudstones in which above the igneous rock, a vesicular structure, probably due to volcanic bombs, was apparent at the ends of the quarry where the overlying rocks were brought down by small faults. The Wearde grits, he said, had yielded no traces of fossils; they resembled the Culm Measure grits, and as the latter are unconformable to the Lower Culm and Upper Devonian in the St. Mellion outlier it was thought for a time that these grits furnished additional evidence of the discordance, as on the neighbouring coast north of Henn Point in one spot beds of chert were interstratified with the vesicular volcanic rocks. Worth had considered these grits volcanic, and that view was entertained by the Director in 1892, but he abandoned it, as the microscope gave no proof of their volcanic origin, and in his papers on the Culm Measures he had ascribed these grits to that series. Detailed work, however, showed that they always accompanied or occurred in the vicinity of volcanic rocks, and were nowhere sharply marked off from the Upper Devonian rocks. They are found between Compton and Crabtree on the north-east of Plymouth, at Wearde, and at intervals from thence to St. Erney, and in a very meagre representation here and there for a few miles farther west. The view now adopted is that these grits were formed in local shoalings accompanying the volcanic episode,

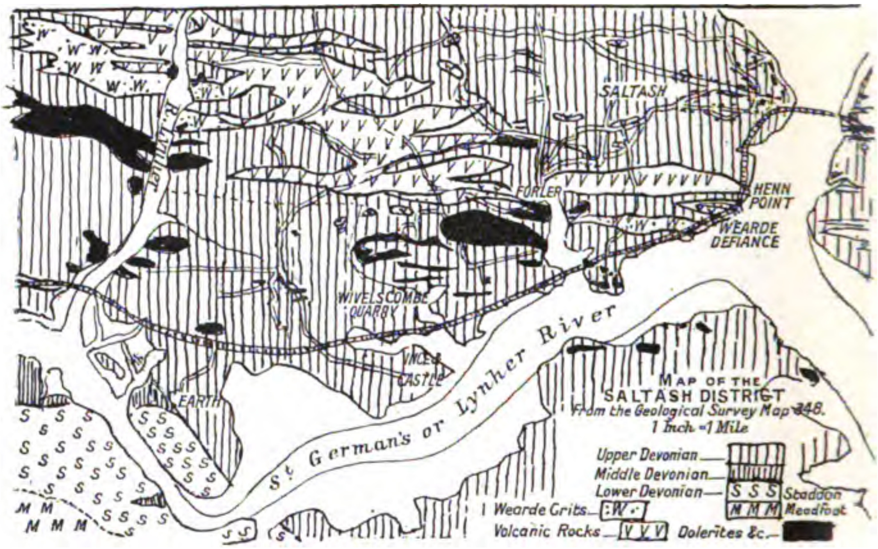

FIG. 8

N.B.—The name FORDER is by an error spelled FORLER on this map.

and partly from erupted materials, and are consequently of Upper Devonian age (see the map, Fig. 8).

After leaving Defiance Quay the party split up into two sections, about 30 proceeding to Antony Passage where arrangements for tea had been made. The remaining members accompanied the Director along the shore to Henn Point, noting associations of tuff and vesicular andesitic basalt in the grey Upper Devonian slates. The tuffs contain large fragments of grey slate in one of which *Styliola* was seen. The vesicular rocks are the same as the pillow lavas exposed in the adjacent railway cutting, and detached pillows were seen in the slates near Henn Point. The advancing tide forbade access to the coast north of Henn Point, where the vesicular lavas are in one spot interbedded with layers of chert in which no traces of Radiolaria were discoverable under the microscope. The triangular patch in which this phenomenon is displayed was at first thought to be let down in a wedge by faults, but this is not the case. After tea at a cottage at Wearde Quay the smaller joined the larger party at Defiance Halt, whence they were taken by Special Rail Motor, shortly after 5 p.m., back to Plymouth.

Monday, April 1st.—On Easter Monday the party assembled at North Road Station and proceeded by the 8.38 train on the L. & S.W.R., to Beer Alston. On arrival they walked by the line for a quarter of a mile through a cutting in Middle Culm grits or greywackes and shales, containing obscure plant remains.

Here the Director gave a short address in which he drew attention to the special feature of the day's excursion, viz., the relations of these plant-bearing grits and shales to the Lower Culm and Upper Devonian rocks in the St. Mellion outlier and the smaller detached masses near Beer Alston, Calstock, Pentillie, and Tamerton Folliot.

Although the Lower Culm rocks are fairly well represented near Pillaton and Herod Down and form the small outliers near Tamerton Folliot, elsewhere they occur as fragments not clearly definable in relation to the plant-bearing grits and shales, which rest for the most part directly on the Upper Devonian.

On leaving the cutting the party proceeded by road through Braunder Farm and thence by the path to North Hooe Ferry, noting a small exposure of vesicular igneous rock in the Upper Devonian slates near the former place. At the Ferry the Upper Devonian slates form the coast, and search was made for a trace of Lamprophyre found on both sides of the Tamar when the Director was engaged in mapping this district, but the only signs discoverable were in wallstones, which however, furnished good specimens.

An hour was spent in transporting the party across the Tamar in boat loads of seven.

When all had landed on the Cornish shore they proceeded slowly towards Haltonquay. The Director pointed out exposures of Lower Culm Measures consisting of chert beds and hard shales, and shales, slates and limestone, and shaly beds containing numerous examples of *Posidonomya Becheri.* Through plication the overlying grits and shales descend to the shore in places. In this section Mr. Howard Fox discovered *Radiolaria* and a foraminiferal limestone with *Endothyra Trochamina, Dentalium* and *Nodosinella.* The Lower Culm rocks are here cut off on the east by a nearly north and south fault running from Haymarsh southward along the course of the river and displacing the continuation of the Pentillie outlier to the Devon shore. At Haltonquay a halt of half an hour for luncheon was made. From here to the summit near St. Mellion the road follows a broad valley occupied by Upper Devonian rocks, the steeper slopes facing south being devoted in places to strawberry culture. At nearly three quarters of a mile west of Haltonquay a small quarry in dark shales and grit with obscure plant traces was inspected. The quarry is in a small outlier of Middle Culm let down by fault. After reaching the high road near St. Mellion the party proceeded to a quarry in hard dark, more or less cherty, Lower Culm Measures beyond Polborder, used locally for road metal. The relation of this patch to the surrounding shales and grits is not clear. From Polborder by the road to Trehill Farm the party traversed Upper Devonian Slates, in which the Director had found numerous Cyprids on the west of the latter Farm. After leaving the road by a path leading south they crossed a narrow isthmus of Culm shales and grits, proved by stones in ploughed ground, which separates one inlier from another. Across it the party proceeded to a second narrow tract of Culm Measures, two sections in which were visited. That on the south showed contorted dark chert beds and siliceous mudstones which bound the main mass of Upper Devonian, exposed in a neighbouring road where purple and green slates were seen. On the north the Upper Devonian Slates of the inlier are bounded by plant-bearing shales and grits, which were shown in a small quarry in the copse not far below the Lower Culm section.

The party then returned to Polborder, where through the exertions of Lieut. Coke arrangements for a plentiful tea had been provided in a barn, where, by good happening, a chapel feast had to be prepared for a later hour. The Director having arranged with the G.W.R.· for special road motors to convey the members to Saltash, these arrived after tea and Plymouth was reached shortly before 6 p.m.

The map (*Fig.* 9) of the St. Mellion outlier is very strongly suggestive of a considerable unconformity between the Culm Grits and shales and the Lower Culm. This is far more probable than any explanation of the phenomena by faults and nearly horizontal thrusts, as in the Newton Abbot area the

Middle Culm rocks contain conglomeratic beds with fragments of Lower Culm cherts.

Dr. Wheelton Hind's correlation of the Lower Culm with the Pendleside series is also suggestive of an unconformity between the Lower Culm and Upper Devonian, which on independent grounds seems by no means improbable.

Tuesday, April 2nd.—On Tuesday the elements hitherto so propitious proved less kindly than the forecasts led us to expect.

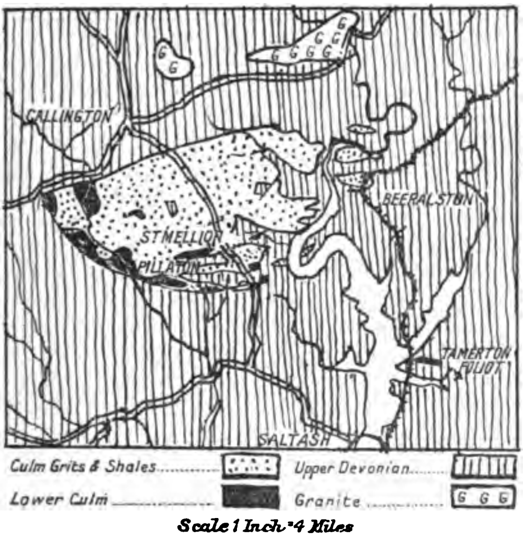

FIG. 9.—THE ST. MELLION CULM MEASURES.

Arriving at South Brent station at 10 a start was made soon after up the road leading northward from the station to sections of purple and buff sheared schalstein tuffs exposed at and near the cross roads south of Harbourneford. The Director said that these rocks were of Middle Devonian age, occurring in the upper part of that series, and that they were associated with limestone near Buckfastleigh. They formed a part, as indeed all the slaty contemporaneous volcanic rocks in the Upper and Middle Devonian of Devon and Cornwall might be said to do, of the Ashprington volcanic series of the Totnes District, discovered by Champernowne and correlated by him with the Nassau Schalsteins. The party were then conducted by a lane on the west of the high road to a quarry at the foot of the dip slopes of the igneous rocks which form the salient feature of Brent Hill. This feature was partly due to the association of sheets of lava with the tuffs as the volcanic rocks passed south-westward on a deflected strike within the zone of contact alteration round the Dartmoor Granite. Rain coming on the party sheltered in the quarry as best they could, and obtained specimens of the Diabase hornfels. After some delay they returned to the lane, where outcrops of axinite epidote rock, a common feature on the borders of the altered volcanic rocks, were pointed out by the Director and many good specimens obtained.

The threatening aspect of the weather then caused some of the members to leave for Brent to catch an earlier train than that given in the programme. The rest ascended the dip slope to the Diabase hornfels crags forming the summit of Brent Hill. Here on the lee of the crags luncheon was partaken of, and the Director pointed out the position of the granite boundary at about three-quarters of a mile to the west. The altered sedimentary rocks, he said, from near Ivybridge by Brent to Gidley Bridge, were shown on the published geological map (sheet 349) as Culm Measures. They consist of hornstones or calc-flintas, and dark and pale rocks with chiastolite. The chiastolite type of alteration had not been recognized in the known Devonian contact areas and the banded hornstones were thought to represent siliceous Lower Culm rocks. Subsequent experience of other granite contact-zones had, however, proved that the calc-flintas through selective metamorphism might occur at any horizon in the Devonian, where fine grained calcareo-siliceous rocks occurred within the aureole; but, as regards the chiastolite types, it was still possible that they might represent altered infolds of fine-grained dense Culm Measures.

The rain still continuing those of the party who had to catch the 3.16 train left after seeing the fine dark tuffs on the lower slope of Brent Hill, the rest proceeded to the vicinity of Didworthy where the light and dark rocks with chiastolite are exposed in a quarry. Those staying on then proceeded to Aish, inspecting on the way an igneous rock containing brown mica. It is probably an altered diabase and not 100 yards from the granite junction.

At Aish calc-flintas or hornstones, diabase hornfels and radiating-actinolite rocks were visible, and in the hard altered rock under Lydia Bridge good specimens of axinite were obtained. At Brent a quick tea was served, and after partially drying their habiliments the diminished contingent who contemplated making one or more of the extra excursions, returned by rail to Plymouth.

Wednesday, April 3rd.—On Wednesday morning, in spite of threatening weather, the President and six members of the party who had remained with the Director, assembled at Millbay Station and took the 9.15 train to Menheniot. Here they inspected the Clicker Tor picrite, which is associated with ophitic dolerite, and finely exposed in the railway cutting at the station. From thence they proceeded to Doddycross, noting, by the way, exposures of grey, purple and green Upper Devonian slates with contemporaneous sheared tuffs. Between Doddycross and Padderbury numerous small *Tentaculites* and impressions of the characteristic Cyprids such as *Entomis serratostriata* and *E. gyrata* were found in the purple and green Upper Devonian slates. Near this evidence of a proterobase sill was noted, and on the hill top near Padderbury Top, where the road is cut through a mass of contemporaneous volcanic rocks, an interesting section was examined. Proceeding southward, and crossing the railway, the party struck across country direct to Catchfrench quarry, in dark grey Upper Devonian slates, in which *Styliola* was found. From here they followed the high road, noting by the way a mass of diabase, to the Seaton Valley, down which they proceeded for half a mile, crossing one of the great structural faults which shifts the Lower Devonian outcrop northward to the vicinity of Clicker Tor. The grey slates of the Upper Devonian are here cut off against rocks of the Meadfoot group, an exposure of calcareous slates and gritty beds with decomposed fossiliferous films attested the presence of the latter group, which further south gave place to the purplish and green variegated Dartmouth Slates, the lowest member of the Lower Devonian in the district. The presence of these slates and of occasional signs of igneous rock in them was apparent on leaving the Seaton Valley and following the road leading to Bindown.

On Bindown hard buff and grey quartz-veined grits make the higher summit levels, and near the road to Looe a quarry worked for roadstone was visited. Here a highly silicified rhyolite was seen in intimate junction with the hard clastic rocks, and specimens were obtained.

A rapid walk of three miles from here northwards brought the party to Menheniot Station, crossing Dartmouth Slates, rocks of the Meadfoot Group, and Staddon Grits on the way.

During their stay some of the members visited Dartmoor, taking train to Bickleigh, and walking from thence across the moor to Dousland.

After dinner on Monday evening the President proposed a very hearty vote of thanks to the Director for his trouble in planning out such an interesting excursion and spoke of the success with which it had been carried out. A vote of thanks was also accorded to Mr. Dibley for the admirable way in which he had performed the duties of secretary in connection with the excursion.

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ORDINARY MEETING.

FRIDAY, APRIL 5TH, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

A. H. Pawson was elected a member of the Association.

The President read a letter which he had received from the President of the Geological Society, announcing that the Society proposed to celebrate its Centenary in September, and inviting the Association to send a delegate on the occasion.

The President stated that the Council had requested him to attend the celebration as the delegate of the Association, and the action of the Council was unanimously confirmed by the members present.

The following paper was then read: "On the Existence of the Alpine Vole, *Microtus nivalis*, in Britain during Pleistocene Times" by Martin A. C. Hinton.

Dr. C. W. Andrews and Mr. A. S. Kennard spoke in appreciation of the value of the paper, and the President thanked the Author on behalf of the Association.

EXCURSION TO BUSHEY AND CROXLEY GREEN, WATFORD.

SATURDAY, APRIL 6TH, 1907.

Directors: JOHN HOPKINSON, F.L.S., F.G.S., and
H. KIDNER, F.G.S.

Excursion Secretary: A. C. YOUNG.

Reports by THE DIRECTORS.

(*By* MR. KIDNER.)

The party left Euston Station by the 1.20 train, and on arriving at Bushey was joined by members of the Hertfordshire Natural History Society. Permission of the L. and N. W. R. authorities having been obtained the party, now numbering thirty, was conducted along the top of the cutting on the west side, where a "trial hole," dug in connection with the proposed new railway from Watford to London, exposed a small section of the fine pale sand of the Reading Beds. The railway lines near the station are about level with the top of the chalk, and the cutting passes through the whole 35 feet of the Reading Beds up to the lowest part of the London Clay. Proceeding over the bridge which spans the cutting a visit was made to Grover's Brickfield in Lower Paddock Road. Here was shown a bed of pebbles, 2½ to 3 ft. thick, of the Reading series, partly Hertfordshire conglomerate and partly loose pebbles and sand. Below was pale sand seen for 3 or 4 ft., having a layer of pebbles. The beds above the conglomerate were obscured and could not be examined. To the right of the pebbles and sand and level with them were seen Reading Clays having the Basement Bed of the London Clay above, with its band of pebbles at the top.

Mr. Kidner remarked that the appearances certainly seemed to indicate a fault, and if the beds were known to be at all regular when traced in their vertical succession and lateral extension, one would not hesitate to conclude that they were faulted; but the Reading sands and clays in the neighbourhood being so variable he felt some doubt, and was led to suggest a possible alternative explanation. Mr. Geo. Barrow, who was present, said he should have no hesitation in concluding that there was a line of fault running approximately north and south, and an examination of the section led to general agreement as to the correctness of this opinion. A downthrow of about 7 or 8 ft. on the east side had brought the calcareous clay and the clays below it against the pebbles and sand. This conclusion was confirmed by pieces of the conglomerate broken off near the fault, which were found to have been altered to "*fault-breccia,*" the pebbles having been crushed and reduced to angular fragments in the faulting, while the siliceous cement showed a whitish, crystalline surface due to crushing instead of the usual smooth fracture. Obviously the fault was to be understood as occurring in the chalk below and involving the superincumbent Tertiary Beds. Mr. Hopkinson and others said this was the best section of Hertfordshire conglomerate known to them *in sitû*, the section near Radlett not being so good. The Association had not previously visited this brickfield, which will be no longer worked.

The Chalk Pit near the Colne Valley Water Works was next visited; about forty feet of chalk is seen. The Geological Survey Memoir, "The Cretaceous Rocks of Britain," Vol. iii, gives a list of fossils from this pit, and refers to it as being probably in the zone of *Micraster cor-anguinum*. This view may now be regarded as confirmed and decided by the finding of several fossils characteristic of this Zone. These fossils are: *Micraster cor-anguinum*, *Inoceramus involutus*, *Echinocorys scutatus*, *Epiaster gibbus*, *Cidaris perornata*, *Bourgueticrinus ellipticus*, and *Thecidea wetherelli*. Most of these were found by Mr. G. F. Brown, a member of the Association. Mr. Brown's fossils, including the Zonal index fossil have been identified by Dr. Rowe, and were shown to those present on the excursion. The *Inoceramus involutus* (not previously recorded from this pit) is part of the flat valve and was also shown to the party. About this fossil there was at first some uncertainty; but Mr. G. E. Dibley is sure about the correctness of his identification, and comparison with a perfect specimen in his possession leaves no room for doubt. The fossils are from the lower part of the pit. The distinctly yellow colour of the chalk in the upper part was noticed.

It may be mentioned that Messrs. C. P. Chatwin and T. H. Withers subsequently visited this pit, and were able to find, in addition to those mentioned above, the following fossils:

Spondylus latus, Sowerby.
Ostrea vesicularis, Lamarck.
Plicatula sigillina, Woodward.
Serpula plana, S. Woodward.
Serpula sp.
Porosphaera globularis, Phillips.
Proboscina ramosa, M. Edwards.
Membranipora sp.
Hippothoa sp.
Webbina

The party next walked to the High Street Station and proceeded by the 3.48 train to Rickmansworth. A walk was taken along the Canal towing path, and by a short foot-path to the extensive gravel pits in Long Valley Wood north of Croxley Hall.

(*By* MR. HOPKINSON.)

A heavy shower of rain greeted the party at Long Valley Wood, and the little shelter to be had was taken advantage of.

Some time was thus lost, but at the first indication of a cessation the extensive sections of the fluviatile gravel here exposed were examined. The gravel is or has been worked for a distance of about half-a-mile in a north-easterly direction. Layers of sand and clay are interstratified with it, and the total thickness of the alluvial deposits is from 20 to 30 ft. They rest on the Chalk in a very uneven manner, so that it is difficult to determine the height of their base, but it appears to average about 30 or 40 ft. above the level of the existing River Gade, on the right bank of which they are situated at a distance of about an eighth of a mile. The Gade is a tributary of the Colne, which here flows from east to west, and is distant half-a-mile at the eastern and a quarter of a mile at the western edge of the gravel in Long Valley Wood, and this gravel should perhaps be considered as part of the alluvial deposit of the Colne in Pleistocene times rather than that of the Gade.

The layers of sand and clay and some peculiar black bands give to the gravel in many places a stratified appearance, but nowhere horizontal for any considerable distance—this conformation being due in places to cross-bedding, but mostly to the irregular dissolution of the underlying Chalk.

The gravel consists for the most part of water-worn flints, some completely rounded, others sub-angular, and also contains quartz and quartzose pebbles. Its most interesting feature is, however, the large number of Palæolithic implements which have been found in it, occurring throughout it, but most numerously near its base. A molar of an elephant, most probably *Elephas antiquus*, has been found at a depth of 26 ft. from the surface, and also a tusk, believed to be of the same species, but this crumbled away when touched.*

At a field meeting of the Hertfordshire Natural History Society in the summer of 1906 a mass of sand and clay, with Sarsen-stones, was seen in the gravel, and then determined by the writer to belong to the Reading Beds. This mass has, so far as possible, been preserved intact for the present visit of the Association, but the large Sarsens which were at the top have fallen down and one of them has been sent to the Hertfordshire County Museum, St. Albans; and the clay above the sand has shifted from the horizontal position in which it was first seen.

The preservation in gravel formed by a river of soft mottled clay and loose white and yellow sand apparently in the position in which they were originally deposited is difficult to account for. The mass when first seen was about six feet in height and ten in width, and the gravel was distinctly arched above it, a darkish band in it showing the stratification very plainly. The gravel has now been worked back for some distance behind this mass and still shows a strongly-marked arch or anticline. The sand was stated by the foreman of the gravel-pits to go down at least six feet below the present level of the surface, which is here close upon the Chalk. This seems to indicate a "pipe" in the Chalk, and it is possible that the whole of the gravel here is, as it were, "piped," that is to say, let down by the dissolution of the chalk, the clay and sand of Reading age having been preserved in their present position by the Sarsen-stones on their surface and in the sand. Another suggestion put forward whilst this structure was being examined was that the gravel has here been washed down from the rising ground above, and, meeting this obstacle, has disposed itself around it in a curved form.

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* Sir John Evans, in *Trans. Herts. Nat. Hist. Soc.*, vol. xiii, p. 66.

Whatever may be the explanation of the preservation of this mass, much interest was evinced in it, and much speculation indulged in. The Sarsens also were carefully examined and were found to be soft in places. One is very large and sharply split across; another is deeply mammillated all over, except possibly on the side on which it lies, which was not seen.

A walk by the canal towing-path to Cassio Bridge and thence by the Rickmansworth Road brought the party to Watford. A substantial tea was served at Buck's Restaurant in the High Street, where Mr. E. T. Newton, F.R.S., presided in the absence of the President. After the usual vote of thanks to the Directors, those returning to London left by the 7.50 train from Watford Junction.

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EXCURSION TO TONBRIDGE.

SATURDAY, APRIL 13TH, 1907.

Directors: MR. J. LEWIS ABBOTT, F.G.S., and
E. W. HANDCOCK, B.SC., F.G.S.

Excursion Secretary: W. P. D. STEBBING.

(*Report by* MR. LEWIS ABBOTT.)

THE party from London arrived at Tonbridge at 2.30, where they were joined by another contingent which had come by other trains, motors, &c., from various parts of the country, in all about fifty in number. A walk was at once made to the top of Quarry Hill, south of the town above the quarry, from whence was displayed the configuration of the Weald extending to the Crowborough Ridge on the south and to the Lower Greensand escarpment on the north.

Mr. Lewis Abbott pointed out that the Association were about to give special attention that year to the two Wealdens, viz., beds of that age, and those which, with the present configuration and features, had resulted from the destruction and redeposition of those beds, and of others which had since been deposited in the area. He then gave what he considered to be the sequence of events in N.W. Europe from the elevation of the Portlandian sea bottom to Palæolithic times.

A large diagram had been prepared by the Directors giving a section from the heights of the central ridge, through the Quarry to the Folkestone Beds, upon the Lower Greensand escarpment. Mr. Handcock then went into further details of the section, and dwelt upon the numerous faults, more especially the large one shown in the quarry, pointing out that it was a strike fault with its hade sloping southward at a somewhat low angle. The upthrow of the Ashdown Sand was probably 150 feet, since over 100 feet of Wadhurst Clay was pierced in the well which started from the bottom of the quarry a few yards to the north. There was nothing in the shape of fault or crush-breccia.

The party then divided into two, one part going into the quarry under the guidance of Mr. Lewis Abbott, and the other part remaining above to hear further explanations by Mr. Handcock. The following is an approximate description of the Wadhurst Clay as seen here in section:

		ft.	in.
Yellowish Clay . . .	Cypridiferous	2	0
Green Shaly Clay . . .	„	2	0
Limonitic Shaly Clay . .	„	0	6
Green Shaly Clay . . .	„	4	0
Shaly Clay	„	2	0
Green Shale	„	1	0
Green and Yellow Shales with layers of ironstone 2 to 4 inches thick, 4 layers of shells 1 to 2 inches		12	0
Hematitic layer with Cyrena		0	3
Brown and Yellowish-brown Shales . . .		5	0
Clay ironstone nodule bed		0	6
Black Carbonaceous Clay, breaking with a short hackley fracture with many Entomostraca *Equisetum Lyelli*, bands of *Paludina* (chiefly *P. sussexiensis*), and *Cyrena* limestone, and layer of Cone-in-Cone, ¾ in. thick, . .	Seen	20	0
"Similar beds" pierced in well		100	0
		149	3

Large quantities of Entomostraca were taken away by members of the party, the lamination of the paper-shales in the upper part being due to these tiny crustaceans. The lower black beds also yielded immense quantities of Entomostraca, the white shells showing up very brilliantly upon the black wet clay.

A drive was then made through Tonbridge to Dene Park to the north. Here the members of the party were entertained to tea by Sir John Hollams, who had invited a party of distinguished guests to meet the Association. A stoke-hole, 10 ft. deep, had recently been dug, the material from which was examined. This was seen to be composed of the wreck of the Lower Greensand, pieces of hard rag, angular and subangular, and sometimes hard-worn chert and Oldbury stone, with here and there an Eocene pebble. Mr. Lewis Abbott also showed a palæolithic worked flake from the same gravel. He pointed out that the deposit was quite different from any ordinary gravel, its composition and mode of arrangement being most remarkable. He exhibited the six-inch contour maps of the surrounding country showing the various patches of gravel (most of which were implementiferous) which lay upon the Greensand escarpment, and it was seen that these extended from the River Shode at Hadlow in a direction towards the Darenth Gorge. It was pointed out that the elevation of this Starve Crow gravel precluded its belonging to the early stage of the Darenth. Notice was then directed to the Valley of the Shode as it exists to-day, the banks of which rise to 700 ft. O.D. on Shingle Hill on the west and to 550 ft. at Hurst Wood on the east. It was further pointed out that as the Hythe limestones were only about 100 ft. thick and that their base at Plaxtol Spout was 550 ft. lower, it followed that the valley was now a syncline; a fact which, despite sections to show it, escaped the notice of the Survey. A few yards north of the first another section was opened which showed altogether different material, and could not be classed as a gravel, being composed of a confused mass of clay and sand carrying hard-worn boulders of Lower Greensand débris. Mr. Lewis Abbott contrasted this with river deposits and said he could suggest nothing but that it had been torn off the face of the Lower Greensand escarpment and forced up into this huge hummock at an elevation of nearly 300 ft. O.D., with a thickness of over thirty feet, covering several square miles, under glacial conditions, which conditions he contended were supported by extensive evidence on the escarpment and in the Holmesdale Valley. It was during this time when a glacial tongue was piled up upon the Lower Greensand escarpment in a manner absolutely identical with a case that he had in his mind in Alaska to-day that the extraordinary downthrow occurred, which reversed the direction of the Shode, and carried its waters into the Ightham Fissure, under those severe climatic conditions shown by the arctic facies of its fauna. Mr. Handcock has since made careful analyses of the material from the second pit, which show the materials to have been derived from the Lower Greensand, and not from the upper sandy member of the Weald Clay, as was once claimed. Further details on this question will be published later.

Before leaving, the President, in the name of the Association, moved a vote of thanks to Sir John Hollams, both for his hospitality and for so kindly allowing the party to inspect these interesting sections. He asked the members to extend the vote to Mrs. Hollams, who had been so kind in entertaining them. The vote, needless to say, was carried by acclamation.

Starve Crow brick pit was next visited, by the kind permission of Mr. T. Collins, the steward of Lord Derby, who had had some further excavations made for the occasion. Mr. Handcock here pointed out that although no real zonal work had as yet been done in the Weald Clay he thought the lower band of *Paludina elongata* was about 200 ft. from the base, and on about the same horizon as it occurs at Biddenden. Here, however, there were two beds of Cyrena limestone at intervals of about ten feet, the lower one yielding *Planocera strombiformis*, Schlott, while a little higher up two bands of *Paludina elongata* limestone occur, these also being separated by about ten feet of shaly, somewhat sandy clay, of a dull yellowish-brown hue. About five feet above this last there occurs a band of cone-in-cone structure about three-quarters of an inch thick. The party then walked back to Tonbridge, where after tea in the Council Chamber in the Castle, kindly lent for the occasion by the Tonbridge Council, a visit was paid to the Museum. A hearty vote of thanks was accorded the two Directors, and a return was made to London by the 7.25 train.

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New Ordnance Survey, Sheets 287 & 303, 1s. each.
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1879. "Record of Excursions of the Geol. Assoc.," pp. 37-40 and 43.
1888. "Prestwich's Geology," vol. ii, p. 259 (for the fault).
1894. ABBOTT, W. J. L.—"Ossiferous Fissures in the Valley of the Shode," *Quart. Journ. Geol. Soc.*, vol. l, p. 171.

EXCURSION TO LANE END, BUCKS.

SATURDAY, APRIL 20TH, 1907.

Director: H. J. OSBORNE WHITE, F.G.S.

Excursion Secretary: T. W. READER.

(*Report by* THE DIRECTOR.)

THE members, about 18 in number, assembled at West Wycombe Station shortly after 2.0 p.m., and walked westward, through the picturesque village, to Myze (or Mice) Farm on the Oxford Road. Here they turned into the narrow lane leading up to Wheeler End Common, and having listened to the Director's remarks on the principal physical features of the neighbourhood, they turned their attention to the Chalk exposed, at intervals, in the banks of the lane. Despite the small depth and overgrown condition of the sections, it was found possible to trace a fairly complete succession of beds, from the firm, greyish-white chalk of the higher part of the *Terebratulina*-zone up to the softer, white and flinty chalk belonging to the lower part of the zone of *Micraster cor-anguinum*; the thin but persistent marl-band at the base of the *Holaster planus*-zone, and the Chalk Rock, a few feet above that band, being easily recognisable. The only noteworthy fossil seen was an example of *Holaster placenta* from the *H. planus* beds just above the Chalk Rock.

By the gates of Denham Farm, where the lane opens upon Wheeler End Common, two blocks of Sarsen were noticed, one containing numerous worn flints. In the course of a general discussion on the derivation of such pudding-stones in the Chilterns, it appeared that some of the members were disposed to refer them to the Reading Beds, while others (including the Director) thought that they were more likely to be remnants of newer Tertiary rocks (*e.g.*, Bagshots), and that a third party was inclined to regard them as cemented masses of drift-gravel.

The stony character of the Clay-with-Flints which underlies Wheeler End Common was apparent along the excursion route, where the thin, goose-bitten grass failed to hide the sterile drift.

In a pit opened in the side of the little hill of flint pebbles, to the west of the cross-roads at Bolter End, the Director gave some account of the rocks which compose the important Lower Eocene outlier of Lane End, and of the dislocations which they have suffered.* With reference to the mass of pebbles exposed, to a depth of 10 or 12 ft., in the sides of the pit in which the party were standing, he remarked that he agreed with Messrs. Whitaker and H. B. Woodward in thinking it to be of Eocene age; and Mr. H. W. Monckton, who was present, was also inclined to share this view. The President (Mr. R. S. Herries), however, while admitting the Eocene origin of the pebbles, suggested that the deposit might be as well, or better, interpreted as a reconstruction, due to the accumulation in a hollow of the washings from one or more thinner Eocene pebble-beds formerly outcropping at a higher level in the vicinity; and that its present occurrence on a hill might be ascribed to the resistance which such bodies of stones commonly offered to denudation. He had in mind certain reconstructed pebble-beds of the Bagshot District.

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* See W. Whitaker, "The Geology of London," vol. i, p. 183. Also forthcoming *Geol. Survey Memoir* on Sheet 254.

In reply, the Director contended that the bed was too homogeneous for a reconstructed deposit. Had the material accummulated in the manner suggested by the President some sub-angular flints, quartz pebbles, bits of Sarsen, or other common constituents of the local drift-gravels, would surely have been incorporated. A close scrutiny had failed to reveal any constituents probably referable to the drift in the body of the pebble-bed, though a sprinkling of such extraneous matter occurred in the thin soil and wash near the surface. Moreover, the structure of the bed, as shown by the gradation in the size of the pebbles, resembled the effects of current or wave action much more closely than those of rain-wash and soil-creep. His belief that the bed was a Reading shingle-bank, strictly *in sitû*, remained unshaken.

Quitting the pit, the party next inspected a poor exposure of part of the Reading "bottom-bed" in the banks of the road leading from Bolter End cross-ways to Fingest. The bed there contains angular blocks of very hard yellowish and grey limestone (altered chalk) in a matrix of fine light-coloured calcareous sand and clay. In many respects this deposit resembles one which is to be seen near Bedwyn in Wiltshire, and which was described, many years ago, by Mr. Whitaker in his paper "On a Reconstructed Bed on the Top of the Chalk and underlying the Woolwich and Reading Beds."*

In the underlying flinty chalk of the *M. cor-anguinum*-zone numerous small fissures filled with calcareous sand containing microzoa, prisms of *Inoceramus*-shell, and other organic débris from the enclosing rock, were noticed. A pipe lined with a similar sand had been pointed out, near Bullock's Farm, earlier in the afternoon.

A short walk south-eastward brought the party to the Lane End sand-pit, which was described by the Director in the PROCEEDINGS for 1899 and 1906. With the enlargement of the working the section figured in 1906 had undergone considerable changes in detail, but it still clearly showed the pebbly, glauconitic, horizontally-stratified Basement Bed of the London

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***Quart. Journ. Geol. Soc.* vol. xvii (1861), p. 527.

Clay resting evenly, but unconformably, upon the gravelly sands of the Reading Series. A new excavation in the Reading Beds, made in the floor of the main working during the early spring of the present year, showed the lenticular masses of rough gravelly material rising westward and thinning out upon a bank of yellow sand. The section seen by the Association in 1899 lay a few yards farther to the west and exhibited none of the gravelly beds.

The members examined the excavations with some care, and although at first inclined to regard the confused stratification of the Reading Beds with suspicion, and to question the age of the overlying glauconitic loams, they eventually accepted the Director's reading of the section which formed the principal objective of the present excursion.

After tea at the adjacent "Old Sun" Inn, the President, in concluding a review of the afternoon's work, proposed the customary vote of thanks to the Director, and this having been passed and acknowledged, the party returned to West Wycombe by Park Lane and the pretty hamlet of Towerage.

On the way back a few exposures of Upper Chalk were noticed in passing; and from a point a little to the north of Towerage there was obtained a singularly pleasing prospect in which a succession of steep, darkly-wooded spurs, overlooking Bledlow Bottom, formed a vista that led the eye onward to a fresh green down rising against the sky at the far end of the valley. The sharp outlines of distant features gave warning of the approach of rain, and drops were already spotting the dust on the Oxford Road as the party trailed into the railway station.

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Geological Survey Map, Index Map, Sheet 12.
Ordnance Survey Map, New Series, Sheets 254-255.
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1890. PRESTWICH, J.—"On the Relation of the Westleton Beds, etc.," *Quart. Journ. Geol. Soc.*, vol. xliv, p. 140.
1896. SALTER, A. E.—"Pebbly Gravels, from Goring Gap to the Norfolk Coast," *Proc. Geol. Assoc.*, vol. xiv, p. 392 (part 9).
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1906. WHITE, H. J. O.—"On the occurrence of Quartzose Gravel in the Reading Beds at Lane End," *ibid.*, vol. xix, p. 371 (part 9).

EXCURSION TO AYLESFORD AND ALLINGTON.

SATURDAY, APRIL 27TH, 1907.

Director: C. W. OSMAN, M.I.C.E.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR.)

THE party left Cannon Street, S.E. & C.R., at 12.54 p.m., and, mustering 34 on arrival at Aylesford, adjourned to the Goods Yard, where the Director from a convenient crane base explained to the members, with the aid of diagrams and models, the object of the excursion, namely the study of the course of the River Medway in the neighbourhood of Maidstone.

The Director said that in order to understand the course of the Medway it was necessary to go some way back in geological time and to consider the general question of the origin of the Weald.

The history of the Weald of Kent and Bas Boulonais began with the close of the Oxford Clay, at which time a general slow sinking of the area from a little south of Chatham occurred, and this continued throughout the whole of the period between the Oxford Clay and the deposition of the Gault. In describing this subsidence Mr. Whitaker had pointed out that the loss of strata from a point 33 miles south to Chatham was no less than 3,300 ft.* Professor W. Boyd Dawkins also gave an instance of a similar loss of strata more to the west, † so it appeared that a great wedge-shaped mass of strata, mostly clay, existed under the Weald Clay between the Oxford Clay and the Gault. In considering the effect of this the 30 ft. of Folkestone Beds found in the Chatham boring could be disregarded. Above the Folkestone Sands the Gault and the Chalk had been continuously deposited over the whole of South-eastern England.

The next stage in the history of the Weald occurred at the close of the Chalk period, when, apart from the general continental, upward movement, a special elevation in the Weald, of a long, oval, dome-shape, occurred, and the sea began its work of planing down, forming the Lower Eocene Woolwich and Oldhaven pebble beds from the flints washed out from the dome. ‡ The perfect oval shape of these pebbles was doubtless due to the strong currents in the great Bay of the Eastern Sea of the period. This attack of the sea continued, sometimes on the north and sometimes on the south side, almost continuously throughout the Eocene and Oligocene periods, with the exception of the London Clay period, when the whole of the Wealden area appears to have been submerged.*

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* Trans. S.E. Union Scientific Societies, 1899, "The Deep-seated Geology of the Rochester District."

† "Royal Commission on Coal Supplies, Final Report 1905," Diagrams.

‡ W. Whitaker, *Mem. Geo. Survey*, 1889, vol. iv, p. 216.

Precisely what happened in the Miocene period is not known. It is usually assumed that our area was a land surface, but more probably the denudation of the Weald was being completed. However this may be, the intimately connected Lower Pliocene sea completed the plane of denudation out of which the present surface of the Weald is carved.† This plane of marine denudation would seem to have been a submerged plateau of about 20 fathoms, swept by strong currents which removed all traces of chalk pebbles, and across which the Lenham or Diestian sand advanced in a horizontal direction until its margin corresponded nearly with the centre of the Weald, when a further important movement occurred forcing the Wealden area above the sea level and bending the Diestian sands somewhere along a line south of the lower Thames valley. With this movement the modern history of the Weald appears to commence.

The older geologists who accepted the plane of marine denudation were much puzzled to account for the transverse direction of the river courses across both hard and soft rocks, and to meet the case assumed that the rivers would follow the lines of transverse anticlines, as the effect of these would be to cause the lines of outcrop on the top of the anticline to be lower down the dip-slope than normal. Mr. Topley, however, has shown‡ that this assumption is not correct and that the rivers usually follow lines of synclines, but he gives no explanation of how this came about, and leaves us with the plane of denudation on which the synclinal lines of outcrop would be, in the centre, higher up the dip-slope than normal, so that subaerial erosion on such a surface would cause the rivers to trend away from the synclines; but such a case does not exist, and some further explanation is therefore necessary. This difficulty was further illustrated by two models.

The later Eocene and Miocene times were periods of great volcanic activity in North Ireland and West Scotland, where volcanoes more than rivalling Etna were formed, and also in early Pliocene times there were tremendous mountain-forming movements in progress such as caused the making of the Alps, and also the further elevation of the Carpathians and Himalayas. The result of these masses being piled up was to upset the equilibrium of the earth, and to restore this certain earth movements followed; amongst these were the subsidence of the eastern area forming the North Sea, the lower Thames valley, and the formation of a remarkable series of monoclinal roll disturbances in a nearly east and west direction, which Dr. C. Barrois calls "The Folding of the Downs." A diagram was exhibited showing some sections across these rolls, near the line of the North Downs by Mr. Whitaker and Mr. Topley, and across the South Downs by Mr. W. H. Bristow, through Mount Caburn, near Lewes, and the coast section of the Isle of Purbeck. It was pointed out that though the dip of the beds on the north and south sides of the Weald was reversed, these monoclinal rolls were precisely similar in character and generally had the peculiar feature that when denuded they showed lower beds to the south side of the disturbance. Such monoclinal rolls are not found in the centre of the Weald, and from the more sandy nature of the Hastings Beds we should not expect them, but here an equally remarkable series of predominating easterly and westerly faults are found. Mr. Topley states that on Sheet 5 the faults running approximately in an east and west direction amount to 260 miles, and faults approximately north and south only to 30 miles.* Their parallelism, however, at once suggests a connection with the monoclinal rolls, and if from an examination of these faults we find that lower beds predominate on the south side we shall have established another strong connection with the rolls, and fill in the gap between the North and South Downs. On Horizontal Section Sheet 77 the faults with lower beds to the south have a total throw of about 1,135 ft., while those faults with higher beds to the south have only a throw of about 530 ft. Again on Horizontal Section Sheet 78 the throw of the faults with lower beds to south amount to about 980 ft., while those with higher beds to the south only equal about 400 ft. throw. There is something more than mere coincidence here and we may safely assume these faults to be the equivalents of the monoclinal rolls, and that the whole of south-eastern England, from the Kingsclere inlier southwards, has been similarly disturbed at one and the same time.

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* A. J. Jukes-Browne, "The Building of the British Isles, p. 222.
† *Ibid.*, p. 237.
‡ "Geology of the Weald," *Mem. Geol. Surv.*, 1875, pp. 277, 278.

Referring to these monoclinal folds Dr. C. Barrois points out† that there have been three important movements which have affected the English Channel region. The first movement, called by Prof. Gosselet "The Folding of the Ardennes," in Lower Silurian times; the second, named by Prof. Gosselet "The Folding of Hainaut," occurred in the Coal Measures period; the third is called by Dr. Barrois "The Folding of the Downs," and he gives the Oligocene as the time of its occurrence. In this date, however, he was mistaken, as borings made by Mr. Clement Reid in the Isle of Wight have since proved that the highest Hempstead Beds are affected by the Monoclinal rolls, so that these must be of subsequent age.

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* "Geology of the Weald," *Mem. Geol. Survey*, 1875, p. 237.

† *Proc. Geol. Assoc.*, vol. vi, pp. 34—37.

The great point Dr. Barrois makes is that these movements have been due to sudden thrusts from the south, causing these disturbances by the relief of tangential strain, also that the long periods between these great foldings were times of comparative quiet; but it does not follow that there were no disturbances between these foldings, and an Oligocene line of disturbance has had a great part to play in producing the geography of the neighbourhood of Maidstone, neither do these sudden movements with quiet intervals preclude Continental elevation and depression, and a clear distinction must be made between Continental movements and those local disturbances which produce small faults and flexures.

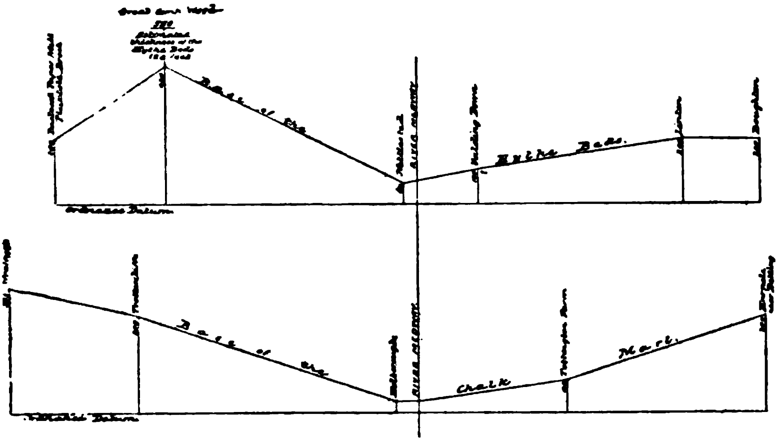

Fig. 10.—Diagram to Show the Syncline of the Medway. —*C. W. Osman, M.I.C.E.*

Scale: Horizontal, 3 miles = 1 inch; Vertical, 600 feet = 1 inch.

Now a thrust without an abutment to act against would simply cause translation, and we find our abutment in that great band of Palæozoic rocks called by Prof. Boyd Dawkins the "South Wales Syncline" shown with other tectonic folds on the map accompanying his evidence before the Royal Commission on Coal Supplies, (Final Report, 1905). At Aylesford we are near the southern margin of this fold, which appears to have remained firm while the tectonic folds to the south subsided and were less stable.

We are now in a position to sum up. We have a great wedge-shaped mass of strata, mostly clay, between the Oxford Clay and the Gault caused by the subsidence of the Palæozoic tectonic folds to the south of the South Wales Syncline. A movement of elevation at the close of the Chalk epoch first formed the Wealden dome, this was probably due to the closing up of that tectonic fold called the North-Devon anticline. Then followed marine and subaereal erosion until, in the Lower Pliocene time, a plane of marine denudation was formed. Upon this plane, with the great wedge-shaped mass of clay beneath, came the sudden thrust and crush of the "Folding of the Downs" acting against the South Wales Syncline, and the result would be that the plane of marine denudation would emerge from the sea and be wrinkled up, where the strata could bend, with monoclinal folds transverse to the direction of the thrust, as in the Weald and other clays; and where sandy, as the Hastings Beds, parallel faults transverse to the thrust would occur. So suddenly would this happen that there would be no time for subaereal denudation to efface the rolls and synclines that would be formed, and the rivers would take these latter for their courses and have generally adhered to them ever since. Great movements have taken place since that time, but these have been mainly of a slow continental character of simple elevation and depression and have not affected the general detailed structure to any great extent.

In the Maidstone district we have in the course of the Medway a fine example of a river flowing in the bottom of synclines. Fig. 10 gives two diagrams showing this by the base of the Hythe Beds and the Chalk Marl respectively. The base of the Hythe Beds is given by Mr. Topley * in illustration of the synclinal course of the Wealden Rivers. The syncline of the base of the Chalk Marl is not so clear, but undoubtedly exists, the line of the diagram is taken down the dip slope from Trottescliffe to Holborough and thence up the dip to Harpole Farm. Now if we join Trottescliffe and Harpole Farm by a straight line we get the true strike, as both places are cut by the 300 foot O.D. contour, but in spite of an upward disturbance we find that the base of the Folkestone Sands only touches the 100 foot contour near Larkfield, more than a mile south of the line of strike; the thickness together of the Gault and Folkestone Sands is about 200 ft., so that the base of the Chalk Marl would be only 300 ft. O.D. if produced to this point, and therefore a synclinal exists here as well.

Fig. 11 shows a section taken in the opposite direction to the diagram of Fig. 10, being drawn from near Kit's Cotty House in a south-westerly direction to the Hermitage, and thence due south to across the River Beult, so that the Medway is twice crossed. At Messrs. Brice's Quarry the base of the Hythe Beds cuts Ordnance Datum; near the Hermitage the level of the ground is 275 O.D., here there is a thin layer of gravel, a sign only of Folkestone Beds and the Sandgate Beds, say, altogether, 20 ft. The full thickness of the Hythe Beds given by Mr. Topley is 70

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* "Geology of the Weald," *Mem. Geol. Survey*, p. 277.

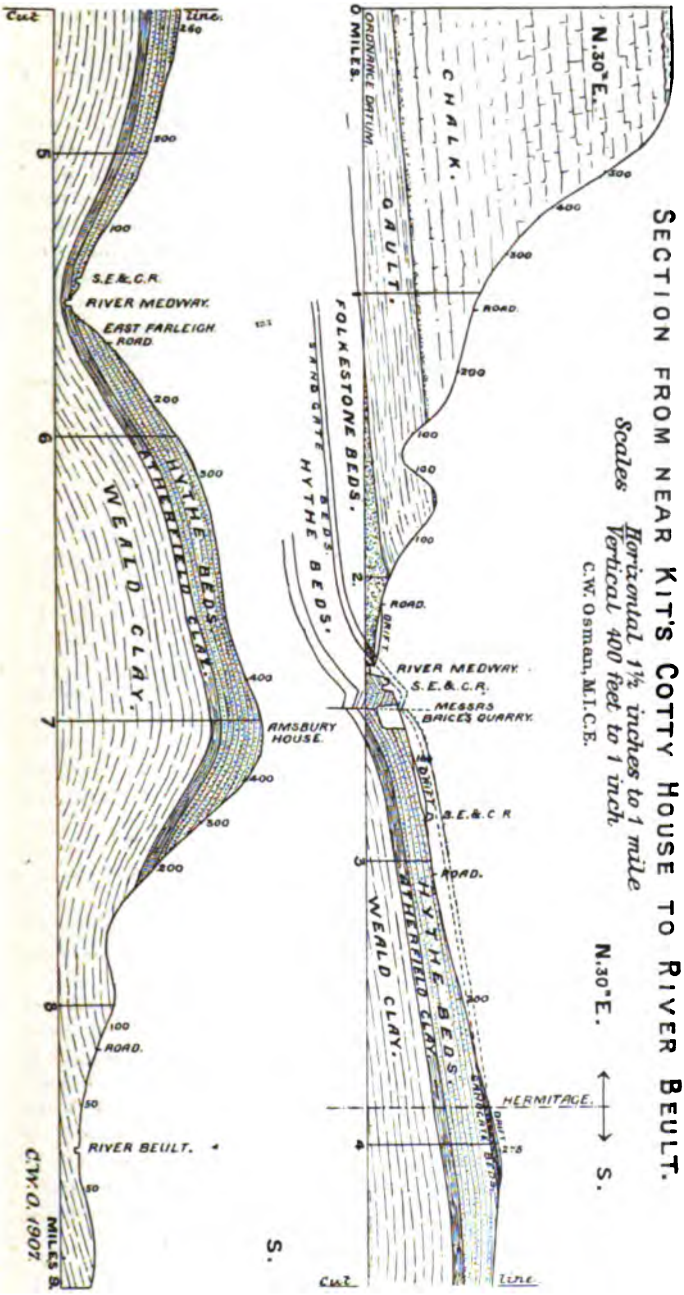

FIG. 11.

SECTION FROM NEAR KIT'S COTTY HOUSE TO RIVER BEULT.

Scales *Horizontal* 1½ *inches to* 1 *mile*
Vertical 400 *feet to* 1 *inch*

C.W. Osman, M.I.C.E.

or 80 ft. * so that the base cannot be less than 175 ft. above O.D. and is still rising to the south. Where the Medway crosses the line of section, near East Farleigh, it is on the Atherfield Clay, and the base of the Hythe Beds is only between 30 and 40 ft. above O.D., showing that the Hermitage ridge is an anticlinal roll of the Weald Clay. From East Farleigh the ground rises very rapidly southwards to about 430 ft. O.D. at Amsbury House; allowing the full thickness of the Hythe Beds with an increase to the south, say 100 ft., the base cannot be less than 330 ft. O.D.; so that at East Farleigh the Medway runs in a strongly pronounced syncline. Going south from Amsbury House the outcrop of the Hythe Beds is only about 200 ft. O.D. Therefore this ridge also must be a roll of the Weald Clay. These anticlinal ridges, both running in an East and West direction, terminate by dipping down to the Medway. The Northern or Hermitage anticline, as far as our area is concerned, commences on the West at the Plaxtole Brook, and ends to the East of the line of section (Fig. 11), between Allington and Maidstone The Southern or Amsbury House anticline commences at the Medway, opposite Nettlestead, and runs East to about 2 miles south of Harrietsham, where it is deflected towards the E.S.E., to form the south side of the syncline of the Stour. These two anticlines overlap each other and the Medway flows between.

Now a long line of disturbance with a dip from 10 to 15 degrees to the N.N.E. runs parallel with the outcrop of the Chalk and Gault, from near Wouldham to near Charing. This disturbance is parallel to the Oligocene depression which brought the Mediterranean to our shores, and also to the estuary of the great Oligocene river, and was doubtless formed during that age. The section (Fig. 11) crosses this disturbance at about 2¼ miles (it can be clearly seen at Messrs. Brice's Folkestone Sand-pit, on the right bank of the Medway, less than a quarter of a mile east of the line of section). Against this Oligocene line of disturbance the Hermitage anticline is stopped with a considerable amount of contortion as seen at Messrs. Brice's quarry (Fig. 12). The Amsbury House anticline also runs east by south up to this same Oligocene line of disturbance near Harrietsham, which it considerably faults and throws out of position.

A line of disturbance, such as this Oligocene one, acts as a stiffener amongst the rocks and offers resistance to any force impressed upon it from any but a normal direction, precisely in the same way as a bend in a piece of tin stiffens the plate in every direction but the bend itself. The Hermitage and Amsbury House anticlines are rolls obviously part of the east and west disturbance of the "Folding of the Downs" in Pliocene times at the crush up of the plane of marine denudation, and these rolls, together with the older Oligocene disturbance, give us a beautiful

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* "Geology of the Weald," *Mem. Geol. Survey.* p. 120.

illustration of the effect of a force impressed on a diagonal line of resistance producing overlapping and parallel replacement of lines of flexion.

The course of the Medway in our area can thus be accounted for by synclines from its entering into the Lower Greensand near Yalding as far as Maidstone; and also its exit through the syncline of the Chalk Marl at New Hythe, but there remains a small portion of its course in a westerly direction which the simple syncline theory does not readily explain. On the 1-inch map there is shown a small fault in an east and west direction at Preston Hall. This fault is somewhat peculiar in that the strata both on the north and south sides dip down to it, and the throw itself is very slight. The line of the section (Fig. 11) cuts across the eastern extension of this fault, and the dipping of the rag-beds towards the south may be seen in the S.E. & C. Railway cutting near Bridge No. 935, while the dip to the north can be well seen in Messrs. Brice's quarry. Doubtless this is one of the results of the meeting of the Pliocene Hermitage roll with the older Oligocene Wouldham-Harrietsham fold, with the result that the crush together formed the double dip down to this Preston Hall fault. This double dip would be produced up to the surface of the denudation plane as a small valley, and so induce the original course of the Medway. Since that time the Medway has cut its channel down the dip slope of the beds to its present position.

When the Medway commenced to run as a river at the time of the Pliocene southern thrust, it was, of course, at a very much higher level, higher than the Chalk crest, and the Gault plain corresponding to the Snodland brook marsh was some miles to the south; the subsequent subaerial erosion has left its traces in patches of drift and gravel at various levels, though the highest of these remains in our neighbourhood is not more than 330 ft. O.D. at a patch two miles W.S.W. from the Hermitage. The section (Fig. 11) cuts three of these drift patches, the highest shown being at the Hermitage itself. Great as has been the amount of subaerial denudation of the Medway valley as shown by these drift patches, we should, however, allow a considerable credit on account of the amount of the original synclinal valleys formed when the course of the Medway was originally determined. Some idea of the amount of this credit allowance can be obtained from the dip of the beds, where the section (Fig. 11) crosses the Medway at East Farleigh.

Some discussion ensued regarding the general question, and the President stated that the points raised were of great interest and covered a wide field, and that after they had seen the evidence that could be obtained during the afternoon, they would be in a better position to appreciate the Director's views. Personally, he was under the impression that the Pliocene sea did not occupy the whole of the Wealden area.

The party then walked to Preston Hall Quarries, where they were received by Mr. and Mrs. Bensted. Mr. Bensted unfortunately, owing to a recent accident being unable to walk, could not remain with the party. The President reminded the members that Mr. Bensted was a very old friend of the Geologists' Association, and many years ago acted as a Director of an Excursion to Maidstone. In reply, Mr. Bensted said it gave him great pleasure to meet the Geologists' Association again after so many years. It was over thirty years ago—in April, 1872—that, with Professors Rupert Jones and Tennant, he directed a party of the Members who visited the Charles Museum, and his *Iguanodon* Quarry at Allington, and also another of his quarries, and he hoped to see the Members again soon.

At these extensive Preston Hall quarries the Hythe Beds are seen dipping in the most regular manner possible very gently towards the north without any sign of disturbance. Over the whole of the west quarry the Hythe Beds come to the surface without any drift, but in the east quarry a considerable covering of drift sand and gravel occurs, and in the north-east angle possibly the Sandgate Beds are *in situ* under the sandy drift. Fossils, chiefly from the lower lanes of Hassock, were found by the members in fair quantity. After a vote of thanks to Mr. Bensted the party proceeded south to Messrs. Brice's quarry near White House Farm, here the Hythe Beds are seen much disturbed, and some idea of the extent of this can be obtained from Fig. 12. Going on to the south the party inspected Messrs. Chittenden and Simmon's quarry on the west side of the railway, opposite Allington Church, where the beds again become more regular but with a dip to the east towards the Medway. Here also may be seen the commencement of the brick earth pipes. Still farther to the south the party reached the S. E. & C. Railway quarry at the east end of the Hermitage roll. This quarry is between the North Kent and Maidstone East Railway lines, and where the Medway makes a sharp bend and comes close to the railway. At this quarry numerous brickearth pipes are found running in a north and south direction, and the Hythe Beds between are inclined sharply down towards the east and the river. The Director pointed out that while doubtless some of this inclination was due to underground water dissolving away the ragstone, tilting the beds and letting down the drift and gravel into the pipes, still no such action could account for the sharp down to-east flexure that can now be seen without a break due to the pipes, and that it was most probable that the fissures now forming the pipes were opened by the breaking across of the hard ragstone beds by the crush of the stoppage of the Hermitage roll against the Oligocene disturbance.

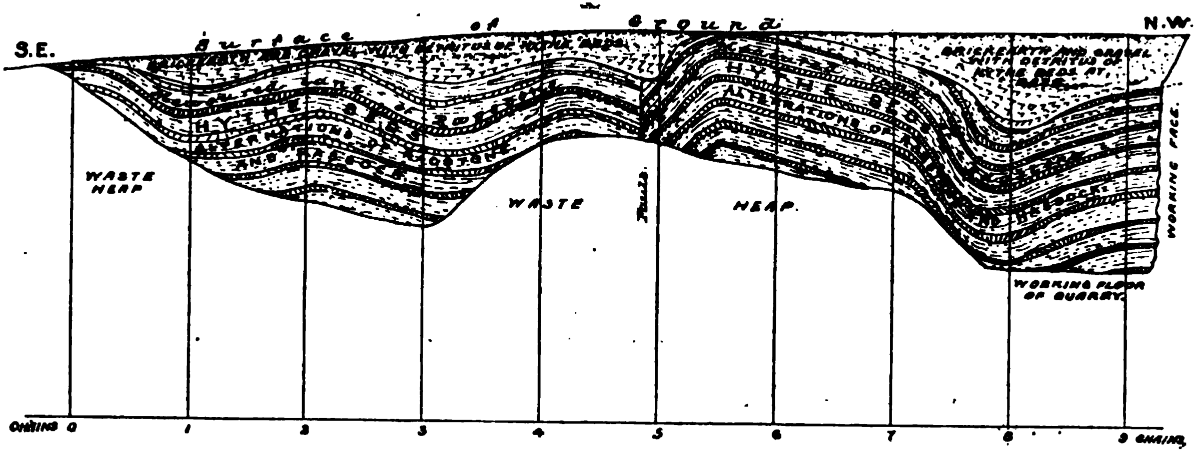

FIG. 12.—SOUTH-WEST FACE OF MESSRS. BRICE'S QUARRY, ALLINGTON, KENT, SHOWING FOLDS FROM TANGENTIAL PRESSURE.—*C. W. Osman, M.I.C.E.*

Datum line about Ordnance Datum.

Scale: Horizontal, ⅝ inch to 1 chain; Vertical, 1 inch to 40 feet.

A very hearty vote of thanks was here accorded the Director for a most interesting excursion. The Members then walked to Maidstone where they enjoyed an excellent tea and left for London by the 7.41 p.m. train.

Fossils collected by Members of the Association in Mr. Bensted's Preston Hall Quarries (Hythe Beds). Identified by E. T. Newton, F.R.S., F.G.S.

WEST QUARRY.

Ammonites (Acanthoceras) martini, d'Orb.
Ancyloceras gigas, Sow.
Nautilus radiatus, Sow.
Belemnites sp.
Pleurotomaria gigantea, Sow.
Exogyra conica, Sow.
Exogyra sinuata, Sow.
Gervillia anceps, Desh.
Myacites sp.
Pecten orbicularis, Sow.
Trigonia ornata, d'Orb (very abundant).
Wood.

EAST QUARRY.

Ammonites (Acanthoceras) martini, d'Orb.
Ancyloceras gigas, Sow.
Nautilus radiatus, Sow (very abundant).
Pleurotomaria gigantea, Sow.
Exogyra sinuata, Sow.

N.B.—No *Trigoniæ* were noticed in this quarry. The lower part was, however, full of water.

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ORDINARY MEETING.

FRIDAY, MAY 3RD, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association :

Malcolm Burr, B.A., A.R.S.M., F.G.S., Simeon Priest, F.G.S., Browne Webb.

The following papers, descriptive of the district to be visited at Whitsuntide, were then read :

1. "The Igneous Rocks of the Bristol District." By Professor S. H. Reynolds, M.A., F.G.S.
2. "The Carboniferous Limestone Sections of Burrington Combe and Cheddar." By T. F. Sibly, B.Sc., F.G.S.
3. "Note on the Coral Zones of the Avonian (Lower Carboniferous)." By A. Vaughan, B.A., D.Sc., F.G.S.

The papers were illustrated with a large series of lantern views.

The President moved a vote of thanks to the respective authors, and referred to the great interest which had been added to the study of the Carboniferous Rocks by the zoning work of Dr. Vaughan in the Avon gorge and its application to other districts by Mr. Sibly. He also congratulated Professor Reynolds on his discovery of igneous rocks of Silurian age in the Mendips. Mr. E. T. Newton also spoke, and Professor Reynolds replied.

A specimen of Nautilus from the Lower Greensand quarry at Preston Hall, near Aylesford, which had been visited by the Association on April 27th, was exhibited by Mr. A. C. Young.

EXCURSION TO FARINGDON.

MAY 4TH, 1907.

Director: LLEWELLYN TREACHER, F.G.S.

Excursion Secretary: GEORGE W. YOUNG, F.G.S.

(*Report by* THE DIRECTOR.)

THE stormy weather of the previous night prevented all but the most ardent field geologists making the early start from town which was necessary. However, about a dozen members and friends met the Director at Challow Station at 11.35, the London contingent arriving by a train specially stopped for the occasion, and the day turned out beautifully fine.

The party drove first to Stanford-in-the-Vale, where, at the western end of the village, they entered the Corallian quarry described long ago by Dr. Mantell in the "Excursions" at the end of his "Medals of Creation." The weathered face of old excavations can be seen surrounding several acres of ground on both sides of the main road to Faringdon, but the only portion worked at the present time is on the east side. The general section exposed is:—

5. Dark loamy soil, in which prehistoric implements have been found.—1½ ft.
4. Coral Rag—Broken corals and echinoderms, with the interstices filled with clay—4 ft.
3. Coralline Oolite—Hard, blue-hearted, flaggy rock with a few small pebbles of quartz, chert and lydian stone, the flagstones alternating with occasional layers of coarse rubbly oolite.—5 ft.
2. Coarse oolitic sand—6 inches, passing down into.
1. Lower Calcareous Grit—Yellow sand, false-bedded in places. Water at bottom of quarry—about 3 ft. shown.

The relative proportions of the hard and soft layers of Bed 3 vary somewhat when traced along the face of the quarry, but the composition and thickness of the other beds, of the coral bed in particular, remain very constant. The coral bed appears to form the sub-soil over some extent of country hereabouts, and was formerly much used for road metal; remains of old workings being noticed in many places near the roadsides. The Kimeridge Clay comes on at the other end of Stanford village, where it is dug for brickmaking.

Although but little time was allowed for collecting, a fair number of fossils were obtained, including, from Bed 2, *Exogyra nana*, *Ostrea* (a medium-sized form), *Belemnites abbreviatus* (worn and covered with small oysters). From the hard crystalline matrix of Bed 3 specimens could only be extracted with difficulty, but *Gervillia aviculoides*, *Trigonia perlata* and teeth of *Lepidotus maximus* were noted. The Corals in Bed 4 were chiefly belonging to the genera *Thecosmilia*, *Thamnastrea* and *Isastrea*, in rather poor condition, associated with *Cidaris florigemma* (tests and spines), *Pseudodiadema versipora*, *Lithodomus inclusus*, *Littorina muricata* and *Pecten articulatus*. No division between the palæontological zones could be detected owing to the lack of the zonal Ammonites in place, but a fragment of *A. perarmatus* was found among the oolitic débris of Bed 3, so that either this species occurs here above its proper zone, or the zone of *A. plicatilis* must be extremely thin in this district.

The drive was then continued about a mile farther along the main road to Faringdon to a large quarry near the cross-road from Hatford to Shellingford. The section is much the same as at Stanford, except that the quarry being situated higher up the dip-slope the bottom is free from water, and it can be worked to a greater depth. The lower sands are more current-bedded and, like the overlying oolite, contain a good deal of wood. Bed 3 is rather thicker than at the last quarry, and there are more of the rubbly oolitic layers and much pisolite. Its variable nature prevents any more detailed section being given, as such would only apply to one particular spot, but the whole may be compared with that given by Messrs. Blake and Hudleston, as seen by them in the Workhouse Quarry, Faringdon. Additional fossils were *Pygaster umbrella*, *Echinobrissus scutatus*, *Belemnites nitidus*, *Myacites*, *Avicula*, *Pecten lens* and *Lima læviuscula*. In one part of the quarry the coral bed (4) is largely made up of stiff clay, a small piece of which, when washed, yielded many perfect specimens of *Thecidium ornatum*, spines of *Cidaris spinosa* and Asteroid ossicles. Two claws of *Goniocheirus cristatus* and a tooth of *Pliosaurus* complete the list. No Ammonites were seen in place, but the workmen had put by specimens of *A. perarmatus*, *A. cordatus*, *A. plicatilis* and *A. varicostatus*, all apparently from Bed 3.

Proceeding towards Faringdon the road rises gently but persistently up the dip-slope of the Corallian to the foot of the hill, on the crown of which grows the group of pine trees known as Faringdon Clump. At the top of the first ascent, near the old brickyard, a halt was made for the purpose of observing the physical features of the district. Looking towards the south-west, immediately in front is the little valley which breaches the main escarpment north-west of Faringdon, and running through the town opens out into the Vale of White Horse, near Shellingford. The floor of this valley is here paved with Corallian rocks, and on its opposite side rises the long north-west and south-east ridge of the Sponge-gravel, capped at its southern end by an outlier of ironsands, similar to those forming the highest part of the hill under the Clump. On the eastern side of the ridge the Sponge-gravel rests directly on the Corallian, but on the west, near the village of Little Coxwell, some thickness of Kimeridge Clay comes between. The Sponge-gravel does not appear to cross the Faringdon valley, as the ironsands of the Clump rest directly on Kimeridge Clay, which was formerly worked in the brickyard close by.

A small pit near the road showed a section of the sands. They appeared to be well stratified with thin layers of clay and blocks of cherty sandstone, the harder parts of which are largely composed of small spicules of siliceous sponges, like those figured by Dr. Hinde as belonging to the genus *Geodia.** A sample of the clayey material when washed yielded many pieces of shells, one small *Terebratula* and a fragment of the Bryozoan *Petalopora Cunningtoni*, (Gregory), all completely silicified. Mr. Osborne White noticed grains of glauconite, but there was no trace of calcareous matter. The age of the sands, and of the Sponge-gravel, was at one time a matter of dispute, but it is now generally allowed that they belong to the Lower Greensand, the whole of the deposits probably representing the greater part of that period. In the opinion of the Director, the geological succession of events in this neighbourhood was somewhat as follows: After a wide-spread denudation of the Kimeridge Clay down to within a few feet of its base, a narrow north-and-south channel was cut still deeper and some way into the Corallian Beds. This channel was then filled up with the Sponge-gravel, and over all was laid down a thick mass of the Ironsands. Subsequent denudation has removed the greater part of the last deposit, leaving only a few outliers on the hill-tops at the Clump, Badbury Hill, and near the village of Fernham, while the Sponge-gravel has been preserved almost intact. Although it occupies an area of not more than two miles in length by half-a-mile in breadth, it is doubtful if it ever had a much greater extension, except perhaps towards the north, in which direction it may have rested on the Oxford Clay, if it is correct that fossils derived from that formation have heen found in the gravel.

The party then drove through Faringdon and for some distance along the Highworth road, to a point whence a fine view was obtained of the plain of Oxford Clay stretching away northward across the valley of the Upper Thames, with the dip-slope of the Cotswolds rising beyond. Noteworthy features of the landscape were Badbury Hill on the left, the wooded ridge of Buscot standing up in the plain to the north-west, and the picturesquely-situated town of Faringdon lying along the hillside below the Clump on the right. A disused quarry close to the road showed the Coral Rag running up to the edge of the hill, thus protecting the underlying Oxford Clay, and keeping up the steep northern face of the escarpment.

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* Fossil Sponge Spicules, plate 2. Munich, 1880

Returning towards Faringdon a brief visit was paid to Mr. Bowler's pit in the Sponge-gravel on the north side of the Swindon Road. This is the most northerly exposure of the deposit to be seen, and it is here more than 20 ft. thick. The material is finer and softer than in any of the other pits, the larger fossils, such as sponges, are much less numerous, but there are plenty of the smaller kinds. The Bryozoan known as *Radiopora pustulosa* is particularly abundant.

The brake was left here and the remainder of the programme carried out on foot. Proceeding towards Little Coxwell the old "Windmill" pit, now Mr. Purbrick's, was reached, and found to be as prolific as ever. The Sponge-gravel is almost entirely made up of organic remains, the inorganic portion consisting of fine quartz sand with a few pebbles of quartz, lydian stone, chert, etc. Although the face of the quarry stands up perpendicularly for more than 30 ft. yet the texture of the deposit is fairly loose except in places where it is hardened into crystalline masses parallel to the bedding planes. The absence of finer or clayey material is remarkable. If a sample of the gravel is washed the only discolouration of the water will be from iron stains. It is this quality which gives the gravel its economic value and causes it to be in great request for footpaths and garden walks. It retains its bright colour well, and is so absorbent of water that its surface keeps dry in the wettest weather. As the extent of the workings show it is not only used in the immediate neighbourhood but also exported to long distances.

The fossils may be divided into two classes, the contemporaneous and the derived. Among the latter have usually been placed the Belemnites, but Mr. Lamplugh has questioned the correctness of this arrangement, and comparing them with the *Belemnites speetonensis* of the North of England has suggested that they may be of the age of the Sponge-gravel or some earlier Lower Greensand deposit. With reference to this it should be noted that the Faringdon specimens also resemble *Belemnites nitidus*, a species very common in the Kimeridge Clay of the neighbourhood. On the previous evening the Director had obtained seventy-six specimens of this form which had been found in a well dug in the Kimeridge Clay at Longcot, about two miles south of the "Windmill" pit.

Of the other fossils the most important are the sponges, the larger forms of which were known to early collectors as "petrified salt-cellars." They all belong to the group of Calcisponges, and about eighteen species have been described by Dr. Hinde and Mr. E. C. Davey. Recently the Director has discovered an example of another form, now in the Jermyn Street Museum, which Dr. Hinde thinks is an undescribed Lithonine Sponge, and that sponges of this group have not hitherto been noted from the Lower Greensand.

Greatly exceeding the sponges in numbers, in species, and possibly even in total bulk, are the Bryozoa. These minute organisms occur both as free twig-like objects and also as encrustations on sponges, shells, pebbles, and even on the free-growing Bryozoa, hardly any suitable surface being exempt from their growth. Sharpe and Davey have published lists of the species, many of which they have identified with foreign forms from other horizons, but their nomenclature is sadly in need of revision. Dr. J. W. Gregory has done something towards this in his British Museum Catalogue, but, unfortunately, the poverty in Faringdon specimens of the collection at South Kensington caused several species to be omitted from that work. Mr. W. D. Lang has identified one of the common smaller forms as *Siphodictyum gracile*, a species recorded from the Lower Aptian of Atherfield and the Upper Aptian of Folkestone.

The fossils most sought after by collectors are probably the Echinoderms. Of these, many remains of *Cidaris* are found, but always as detached plates and spines. They are all usually assigned to *Cidaris Faringdonensis*, but there appears to be another species present, the spines of which differ from those of *C. Faringdonensis* by the absence of the long, smooth neck which characterises that form and they rather resemble those of *C. pretiosa*.

The commonest Echinoderm is the *Peltastes*, of which several species have been recorded, but after examining some hundreds of specimens the Director is of opinion that although individuals may be found which appear to differ almost specifically from each other yet the majority are intermediate forms, and as these cannot be ignored it is not very easy to draw a hard and fast line between one so-called species and other. He therefore prefers to call them all varieties of *Peltastes Wrightii*. At the same time it should be remembered that nearly all the specimens are so much encrusted and so difficult to clean that their finer details cannot always be made out. Among those recently discovered are two which, although in general appearance much like *Peltastes*, yet have the apical system of a true *Salenia*. Dr. F. A. Bather, who has kindly examined them, thinks they are nearly allied to *Salenia gibba.* Another Echinoderm, which may be noticed here, is one of which Dr. Bather says: "It is probably one of the *Pygasteridæ* allied to *Pygaster* or *Pileus.* I have not as yet found the species described."

Other fossils include the Brachiopods, which are fairly numerous and have usually been relied on for the determination of the age of the deposit. Lamellibranchs, except those of the *Ostrea* family, are not common, and Gasteropods are almost entirely wanting.

In the short time at their disposal the members were fortunate enough to obtain examples of most of the characteristic fossils, including a good number of teeth and bones of Saurians and Fishes.

By kind permission of Mrs. Roberts the party then took a short cut across some cornfields to a pit on the eastern slope of the ridge, in what is known as the Red-gravel. This material is of a darker colour than the Sponge-gravel proper, owing to the presence of a thin film of iron covering each of its constituent parts, and giving some of the larger fossils a curious velvety appearance. The sand is coarser and pebbles are more abundant, but except in the numerical proportion of the organic remains there does not appear to be any palæontological difference between the two deposits, the only fossil peculiar to the Red-gravel being the Echinoderm *Trematopygus Davidsoni.* The large *Nautilus,* long supposed to occur only in this pit, has been noticed by the Director at least twice in the "Windmill" pit. The Red-gravel is generally considered to overlie the Sponge-gravel, but this is open to doubt, and probably nothing short of a deep cutting joining the main excavations would definitely settle the matter. Near the top of the Red-gravel in this pit are some layers of a lighter colour and looser texture than the rest of the material, a fact which is even more noticeable in a small pit farther to the east across some fields, to which time would not allow of a visit.

Mr. Hunt, who works the Red-gravel pit, had most kindly reserved his recent finds specially for this occasion, so that the members were able to secure some fine specimens of the large *Nautilus,* together with various sponges and other fossils, including two internal casts of a large *Pleurotomaria* and one valve of a *Spondylus,* which Mr. R. B. Newton thinks is near to the *Spondylus Brunneri* of Pictet and Roux, recorded from the Aptian of Switzerland.

The heavily-laden party then returned by Sand Lane to Faringdon for tea, after which the President, in proposing a vote of thanks to the Director, remarked that they had proved it possible to make a one day's excursion to Faringdon successful, and he hoped that, although it was fifteen years since their last visit, it would not be so long before the Association again visited that interesting district.

The members then dispersed to their various destinations, the railway party leaving by the 6.0 train.

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EXCURSION TO CRAYFORD AND DARTFORD HEATH.

SATURDAY, MAY 11TH, 1907.

Directors: R. H. CHANDLER and A. L. LEACH.

Excursion Secretary: A. C. YOUNG, F.C.S.,

(*Report by* THE DIRECTORS.)

THE party, 49 in number, met at Crayford Station at 3 p.m., and walked towards the great gravel pit at Wansant on the northern edge of Dartford Heath. Near the railway the Chalk was noted, overlain by re-sorted Thanet Sand, and higher up the hillside the Thanet Sand was seen *in sitû* just below the working floor of the pit. A small patch of Tertiary pebbles, resting on the Thanet, appears to be the remnant of a drift derived as "run of the hill," from the high ground west of the Heath.

The Directors made the following remarks on the position and constituents of the Dartford Heath drifts.

Dartford Heath lies near the foot of the northern dip-slope of the Chalk, and in the angle between the rivers Cray and Darent, which unite before entering the Thames. The Heath is thus well within the basin of the Thames, and is distant only two miles from the present course of that river. The drift deposits, which include sands, gravels, and brick-earths, rest at from 85 to 100 ft. O.D. on Thanet Sand or, where this has been entirely removed by denudation, upon the Chalk.

Wansant pit shows no brick-earth, but false-bedded sands and gravels upwards of 40 ft. thick, resting on Thanet Sand at 90 ft. O.D. The top layer of gravel—"Dartford Heath gravel" of commerce—consists chiefly of sub-angular flints in a stiff clayey matrix, and rests on a more or less uneven surface of the false-bedded sands. The deposits appear to be fluviatile drifts lying at the same level as the Swanscombe and Galley Hill gravel spreads; contemporaneous and, originally, continuous with them, but now separated from them by the subsequent erosion of the Darent valley. Dartford Heath thus belongs to the highest terrace that can be definitely associated with the drainage system of the present Thames.

The Thames, Darent, and Cray have all contributed material to this deposit, and the influence of the Thames is very strongly shown by the presence of many erratics, which may be traced to the glacial gravels, boulder-clays, and high level gravels of the Upper Thames Valley, and thence into the Midlands and West of England. Excluding the flints, which form the bulk of the gravels, the rocks fall into two groups.

(A) Rocks brought down by the Thames: these include the spotted and liver-coloured "Bunter" quartzites; Crinoidal chert (Carboniferous); "Rhaxella" chert (Oolitic); Radiolarian and reticulated cherts (Bunter); "Tourmaline" grits (West of England); Hertfordshire "pudding-stone"; large Sarsens; pink granites; quartz mica schist; vein quartz; and various weathered igneous rocks and altered sedimentary rocks.

Note —Mr. J. Vincent Elsden, B.Sc., F.G.S., writes as follows on some sections of pebbles from Wansant, submitted to him:

"Dr. Salter and I have looked at the specimens, which are sediments more or less altered. The tourmaline grits and the radiolarian cherts *may* have come originally from the S.-W. of England. The so-called radiolarian cherts are a little uncertain, as such rocks often are.

(1) Fine-grained sandstone, infiltrated with veins of quartz full of *tourmaline needles*—the so-called "tourmaline grit." Possibly a metamorphosed sediment from near an igneous contact.

(2) A silicified sedimentary rock, chiefly made up of areas filled with a fine-grained quartz mosaic, separated by irregular patches of amorphous, possibly argillaceous, material. The structure is only visible under crossed Nicols.

(3) Silicified sedimentary rock, showing structure somewhat resembling some radiolarian cherts (see 5). Sedimentary origin.

(4) Apparently an altered sediment, consisting of alternating laminæ of silica and amorphous matter. Pronounced by Dr. Salter to be probably a pebble from the Bunter.

(5) *Reticulated chert*, recognised by Dr. Salter as similar to some in which Dr. Hinde recognised radiolarian structures. These consist of ovoid patches of paler tint, some of which may be noticed in the specimen. Possibly a pebble of Bunter origin.

(B) Rocks brought down by the Darent: Chert (L.G.S.); Lydian stone; micaceous and ferruginous sandstones, grits, Carstone, and decalcified "Kentish Rag" (Lower Greensand); Tertiary ironstone concretions and shelly conglomerates (Woolwich and Blackheath Beds); vein quartz and pale quartzites. With reference to these last, it may be noted that ovoid grey quartzites occur in the Tertiary Beds at Worm's Heath, whence the Darent probably derived some of its Tertiary material,

Many of the rocks under (B) may have been in part brought by the Thames, since the Lower Greensand chert occurs in high level drifts of the Upper Thames basin.

In addition to the casts, in flint, of Chalk fossils, the gravel contains many fossiliferous pebbles. Mr. E. T. Newton identified the following species in pebbles collected by the Directors:

Rhaxella perforata, *Cerithium* sp., *Protocardium* sp., *Corbula*, *Pecten* sp., *Serpula tetragona.*, *Astarte* sp.; these all occur in "Rhaxella chert" (Middle Oolites).

Crinoid ossicles, *Productus* near *punctatus* (Carboniferous).

Productus sp. (spined), *Modiola* sp., *Bellerophon* (?), *Goniatites* (?), *Cyrtoceras* (?), and a Euomphaloid Gasteropod in quartzose rock of Carboniferous Limestone age.

* *Chonetes laguessiana* (Carboniferous Limestone) and * *Ammonites* [*Cardioceras*] *cordatus* (Oxford Clay or Coral Rag).

The most interesting Chalk fossil was a cast, in flint, of the head of *Bourgueticrinus*, showing casts of the internal cavities and tubes.

---

* The fossils marked thus were found by members of the party in Wansant pit.

With reference to Pleistocene fossils from Dartford Heath little can be said. Some leg bones of mammoth were obtained about two years ago in Wansant, but no shells are known to occur. The corresponding gravels at Dartford Brent and Swanscombe have yielded an abundant fauna, among which may be noted the human remains found at Galley Hill in 1888. Implements are also rare in the Dartford Heath drifts, and those which occur are generally much abraded and apparently have been derived from the older "Plateau" drifts.

The history of the Dartford Heath deposits may be briefly stated. The gravels and sands were laid down near the junction of the Darent and Thames when these rivers flowed nearly 90 ft. above their present level. The gravel consists partly of Cretaceous and Wealden material and partly of erratics which have travelled down the Thames from older deposits in the upper Thames Valley. During a period of erosion brought about probably by slow earth movements, the rivers cut through their old deposits and sub-aërial denudation removed the sides of the ancient valley. Much of the material was re-deposited at a lower level, forming the well known gravels and brick-earths of Crayford.

Mr. E. T. Newton made some remarks on the fossiliferous pebbles. The party then searched the pit for rocks and fossils. Some interesting specimens were obtained, notably the fragment of *Cardioceras*, also "*Rhaxella* Chert" and one specimen of *Chonetes laguessiana* beautifully preserved in Carboniferous chert. A "borer" of the "Plateau" type was found by Mr. M. C. Heys, and a few other slightly worked and abraded flints were picked up.

Since the excursion the Directors have found several specimens of pure white *Rhaxella* Chert.

Along the edge of the pit the Directors indicated some V-shaped trenches full of disturbed gravel in which calcined flints and bones occur; close by, but unfortunately destroyed just before the visit of the Association, was a "hearth" in which they obtained coarse pottery, charcoal and "pot-boilers." Several trenches and "hearths" have been discovered as the working-face of the pit has been cut back. Some fragments of pottery and bones recently obtained were sent up by the proprietor of the pit, but unfortunately the bearer failed to notice the party in time. Mr. A. S. Kennard, who examined the specimens later in the afternoon, identified the pottery as of "Early Iron" or possibly "Bronze" age. It is therefore probably of the same period as certain gold ornaments found in the adjacent pit.

Leaving Wansant pit, the party entered Messrs. T. and F. Martin's pit where, in a railway cutting, the Drift was seen resting on a fairly level surface of Thanet Sand. The western end of the cutting showed the drift trailed down over a hill-slope of Thanet Sand.

On the southern face of this pit was seen the V-shaped trench (7 ft. wide and 5 ft. deep) from which nine gold armlets were recently obtained. Since the first discovery of gold ornaments in 1906, the trench has been cut back some 20 yards, and it still runs an unknown distance towards the open Heath. Mr. C. H. Reed, of the British Museum, kindly informs the Directors that the armlets are "certainly of Bronze Age—between, say 500-1,000 B.C."

The party now walked across the Heath, passing a pond held up by brickearth and noting a line of mounds which may have been thrown up in 1779-80, when a military camp of 8,000 men was formed on the Heath. Some of the mounds look like burial tumps, but Mr. Spurrell, who opened several of them, found nothing in them. The occurrence of neolithic implements in their neighbourhood and the proximity of the "hearths" and "gold ornament trenches" suggest a connection between at least some of the mounds and the prehistoric settlement which existed on the Heath.

In Dartford Heath Brickyard thinly-bedded brickearth, waved and slightly contorted, rests directly on Thanet Sand at about 95 O.D. In Wood's pit (across the road) some 6 ft. of brickearth has been removed over a large area, leaving about 10 ft. of gravels and strongly false-bedded sands, which are separated from the underlying Thanet Sand by a bed of hard ferruginous sand. The brickearth also formerly lay to a great thickness in a trough-shaped hollow beside the pit. Two palæoliths from this pit were exhibited; Mr. A. S. Kennard pronounced one of the "Rockshelter" type; the other was perhaps derived from an older drift.

On the way into Dartford two pits were omitted as time ran short. The last pit visited (100 ft. O.D.) showed the drift resting on a "bull-head" containing huge chalk-flints. The base of the drift here consists of Tertiary pebbles.

A curious "pipe" in the drift was hastily examined, and the President having moved a vote of thanks to the Directors, the walk into Dartford was resumed. Tea was obtained at the "Bull" and the party left by the 7.32 p.m. train.

The Directors wish to express their thanks to Mr. E. T. Newton for identifying the "derived" fossils and for his note on the Arngrove stone; to Mr. J. Vincent Elsden and Dr. A. E. Salter for their notes on the rock sections; and to Messrs. D. T. Corke, T. and F. Martin, and Wood for permission to conduct the Association through their gravel pits.

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NOTE ON SPECIMENS OF "RHAXELLA CHERT" OR "ARNGROVE STONE" FROM DARTFORD HEATH.

By E. T. NEWTON, F.R.S., F.G.S.

(Read at the Wansant Pit, Crayford, May 11th, 1907).

AMONG the fragments of various rocks containing fossils received from Mr. A. L. Leach and Mr. R. H. Chandler, which they had collected from the Dartford Heath gravel, there are three examples of a porous cherty rock which were not easily identifiable. These three are similar in structure and may be pieces of the same pebble. The rock is pitted more or less closely with minute holes, as if made with a pin-point, which need a hand lens to be distinguished. Besides the pittings, fragments of *Ammonites* (*? Perisphinctes*) are to be seen, as well as *Cerithium*, *Protocardium*, *Corbula*, *Pecten* and *Serpula tetragona*. It was at once obvious that, if the last-named fossil were correctly identified, this chert must be of Oolite age. My friend and colleague, Mr. H. B. Woodward, to whom I showed the specimens, reminded me of the paper just published in the *Quart. Journ. Geol. Soc.*, by Mr. Morley Davies, on "The Kimeridge Clay and Corallian Rocks of the neighbourhood of Brill (Buckinghamshire)," and showed me specimens of the "Arngrove Stone" which he had himself collected recently in that locality. The similarity of the "Arngrove Stone" or "*Rhaxella* Chert," which is of Corallian Age, to these Dartford Heath pebbles was soon apparent, for there could be little doubt about the fine pittings that had attracted attention, being of the same nature as those attributed to the spicules of the sponge *Rhaxella*. Having arrived at this point, there seemed little reason for hesitation in regarding these particular cherty pebbles of Dartford Heath as having been derived from the neighbourhood of Arngrove, where the same rock appeared to be *in sitû*.

Being anxious to obtain additional evidence, especially as to the fauna of these pebbles, I consulted Dr. Salter, and among his large collection of Drift pebbles found some pieces exactly resembling those from Dartford Heath, and containing similar fossils with the addition of *Ammonites* (*Quenstedticeras*) *Lamberti*; but these specimens were obtained from the Drift near Cromer, and could hardly, therefore, have come by natural means from Buckinghamshire.

Mr. Morley Davies, in his paper above alluded to, points out that the "Arngrove Stone" is similar to the Yorkshire rock which was described by Dr. Sorby in 1851, and in which he had noticed the rounded bodies that afterwards, in 1890, were described by Dr. G. J. Hinde, and named by him *Rhaxella perforata*. Specimens of Lower Calcareous Grit from Yorkshire, in the Jermyn Street Museum, were found to contain these *Rhaxella* spicules, and the colour and texture of the rock was like some examples from Arngrove, but were not the same colour as those from Dartford Heath and Cromer (*i.e.*, ferruginous buff). Subsequently, Dr. G. J. Hinde very kindly t me examples of "*Rhaxella* Chert" from Scarborough, and o these agreed in colour and texture with our specimens. it now clear that a "*Rhaxella* Chert" of Lower Calcareous Grit age occurs at Scarborough and also at Arngrove ; and that both these cherts are so like these pebbles from Dartford Heath and Cromer that hand specimens cannot be distinguished.

It seems probable, therefore, that the Cromer specimens of "*Rhaxella* Chert" were derived from Yorkshire; and it may be that the Dartford Heath specimens were brought southward by the "Drift" from the same place ; but it will probably be thought more likely that the latter specimens are examples of "Arngrove Stone," which have travelled eastward along the ancient Thames valley.

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(*Continued on page 3 of the Cover.*)

JAN 1C

THE GEOLOGY OF THE APPLEBY DISTRICT, WESTMORELAND.

WITH SPECIAL REFERENCE TO THE AREA TO BE VISITED DURING THE LONG EXCURSION OF 1907.

BY JOHN EDWARD MARR, Sc.D., F.R.S.

(Read July 5th, 1907.)

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I.—INTRODUCTION.

THE geological structure of the Appleby District is of particular interest, for it determines one of the dominant physical features of our island—namely the Pennine Chain or Backbone of England.

The country immediately around Appleby forms comparatively low ground, between the heights of the Lake District to the west and the Pennine scarp to the east. Through this low ground runs the river Eden, and this low country has been termed Edenside by the late Mr. Goodchild.

The general position of Edenside is shown on the accompanying map (Plate II) by the stippled portion of New Red Sandstone extending in a N.N.W. direction from Kirkby Stephen, past Appleby, to within a few miles of the city of Carlisle, where it passes into the north-Cumbrian plain lying east of the Solway.

The map, Plate II (by the late J. G. Goodchild), also shows the distribution of the principal geological formations.

Edenside is geologically a syncline between the Lake District anticline to the west and the Pennine anticline to the

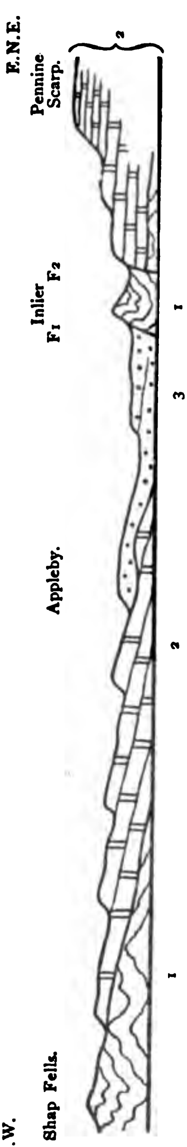

FIG. 13.—GENERAL SECTION ACROSS EDENSIDE.—*J. E. Marr.*
Length of Section about 14 miles.

1. Lower Palæozoic.
2. Carboniferous.
3. New Red Sandstone Series.

F1. Outer Pennine Fault.
F2. Inner Pennine Fault.

east, but the eastern limb of the syncline is cut off by the principal Pennine fault, and accordingly we find, apart from detail, a repetition of the rock-groups which occur to the west of the fault on its eastern side, and the general dip is in an easterly direction, save in the case of the highly convoluted Lower Palæozoic rocks.

Standing on a prominent height near Appleby, we see to the west the Lake District hills of Lower Palæozoic rocks: nearer are the hills between Shap and Penrith, formed by the overlying Carboniferous strata; and the ground on which we stand consists of the yet more recent New Red Sandstone.

Turning to the east the position of the important Pennine Fault is shown by the sudden rise of the great Pennine scarp with the Lower Palæozoic hills of conical shape in the foreground. The fault runs between the latter and the New Red Sandstone.

If we crossed over the Pennine Chain we should reach the New Red Sandstone of the tract around the mouth of the Tees, thus traversing between the fault and Tees-mouth the same rocks over which we pass when walking from the eastern confines of the Lake District, past Shap and Appleby, to the Pennine Fault. The Section (Fig. 13), in which details are omitted, shows the general lie of the rocks to the summit of the Pennine Chain.

The stratified rocks will be described in the order of their antiquity, beginning with the most ancient.

The Geological Deposits found in the Appleby District.

QUATERNARY	Recent (Alluvium peat, etc.). Glacial (boulder clay, sand, and gravel).	
MESOZOIC	Trias	St. Bees Sandstone. Gypseous Sandstones and Marls.
UPPER PALÆOZOIC	Permian	Magnesian Limestone and Plant Beds. Upper Penrith Sandstone. Upper Brockram. Lower Penrith Sandstone. Lower Brockram.
	Carboniferous	Millstone Grit. Carboniferous Limestone Series. Sandstones, shales, and conglomerates.
	Old Red Sandstone (Polygenetic conglomerate).	
LOWER PALÆOZOIC	Silurian	Brathay Flags. Stockdale Shales.
	Ordovician	Ashgill Shales. Staurocephalus and Keisley limestones. Dufton Shales. Corona beds. Borrowdale Volcanic rocks. Skiddaw Slates with Milburn Volcanic rocks.

II.—THE LOWER PALÆOZOIC ROCKS.

The Lower Palæozoic Rocks occur in an inlier to the east of Edenside (see the Map, Plate II, and Section, Fig. 13), extending in a direction nearly north and south from the neighbourhood of Melmerby to the western flanks of Roman Fell, having an average width of about a mile. On the west they are separated from the New Red Sandstone, as already stated, by a great fault, in many respects the most important in the district. This has generally been spoken of as the Pennine Fault, but the Geological Surveyors term it the Outer Pennine Fault, giving the terms Inner Pennine Fault and Middle Pennine Fault to two other faults which we will now notice. The inner fault on the whole separates the Lower Palæozoic rocks from the Carboniferous rocks of the great escarpment, though a few patches of Lower Palæozoic rocks occur to the east of it in one or two valley bottoms, and the Carboniferous rocks on the top of Roman Fell are on its western side. Its throw is not very great. The Middle Fault along the greater part of its course divides two groups of Lower Palæozoic strata, the older lying to the east, and the newer to the west of the fault-line. Section (Fig. 14) shows the effects of the three faults.

(1) *The Skiddaw Slates.*—Along the strip of country between Melmerby and Roman Fell, bounded by the middle and inner Pennine faults, occur rocks which are correlated with the Skiddaw Slates of the Lake District. They consist chiefly of glossy black or greyish badly-cleaved slates with thin grit bands. In a few places, as at Ellergill, are more earthy shales with Graptolites. These, which are apparently newer than the main-mass of slates, are of Arenig age. The main-mass may be partly Arenig and partly of older date, but in the general absence of fossils little need be said concerning it, for we shall pay little attention to its rocks during the excursion.

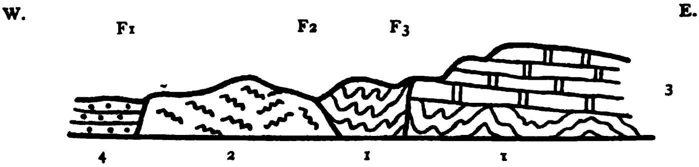

FIG. 14.—SECTION ACROSS THE PENNINE FAULT.—*J. E. Marr.*
Length of Section about 2 miles.

1. Skiddaw Slates.
2. Upper Ordovician and Silurian.
3. Carboniferous.
4. New Red Sandstone.

F1. Outer Fault.
F2 Middle Fault.
F3. Inner Fault.

Above the Ellergill Beds are graptolite-bearing shales with intercalated ashes and lavas, marking the change from the non-volcanic Skiddaw Slates to the volcanic Borrowdale Rocks. These were called the Milburn beds by the late Mr. Goodchild. Certain volcanic rocks at the north-west corner of Roman Fell may be of the same age as the Milburn beds.

(2) *The Borrowdale Volcanic Rocks* (Llandeilo.)—Near the northern extremity of the inlier, and still between the middle and inner faults, is a group of contemporaneous porphyritic and vesicular basic andesites and ashes which are undoubtedly the equivalents of the well-known Eycott Hill rocks, north-east of Keswick; the latter occur some way down in the Borrowdale Series.

The highest rocks of the Borrowdale Series are found in the block between the middle and outer faults, and pass up into the higher Ordovician sediments. They consist of rhyolites and rhyolitic ashes, and form several of the conical hills of the inlier, including Knock Pike and Dufton Pike. On these Pikes they are usually very rotten, and the best exposures are found in the stream-courses, especially in Swindale Beck, where one of the lavas is of great interest. It is described by Mr. Harker as an "eutaxitic" rock with discontinuous bands of crystalline character consisting of clear felspar quartz and decomposition products. It has caught up fragments of an earlier Andesitic lava, and the flow-lines stream around these fragments. The highest bed of this series in Swindale Beck is an ash which is immediately succeeded by fossiliferous deposits, themselves containing ashy material.

The rhyolitic group of the inlier is quite comparable with that which forms the summit of the Borrowdale Series in the Lake District. The general strike of these and the succeeding rocks is W.N.W. and E.S.E., but they are repeated several times owing to faults which cross from the outer to the middle Pennine faults with a general N.E. and S.W. trend. These cross-faults produce five main blocks of strata, one at the extreme northerly end of the inlier north-east of Melmerby, the second with Knock Pike and Swindale Beck, the third with Dufton Pike, Pusgill, etc., the fourth with Gregory and Keisley, and the fifth with Roman Fell and part of Hilton Beck. Each of these blocks displays the rhyolitic series.

(3) *The Corona Beds.*—These consist of ashy calcareous shales, and argillaceous limestones, the latter sometimes largely composed of *Beyrichia.* The beds are seen in their proper position in Swindale between the rhyolitic series and the overlying Dufton Shales, but the most fossiliferous localities are the Alston Moor Road near Melmerby, Pusgill, and the flanks of Roman Fell. In addition to the type fossil *Trematis corona, Lingula tenuigranulata* seems to be confined to this group. The beds are probably of Lower Caradoc age.

(4) *The Dufton Shales.*—Dark grey or black cleaved shales with much calcareous matter, and thin bands of limestone, greatly folded, so that no accurate estimate of thickness can be made, but they are probably not more than 500 ft. thick. They are usually very fossiliferous, with a marked upper Caradoc fauna including *Calymene senaria, Cybele verrucosa, Trinucleus seticornis, Orthis testudinaria.* The best fossiliferous localities are Swindale, Pusgill, Hurning Lane, and Billy's Beck.

(5) *Keisley and Staurocephalus Limestones.*—White, grey, and pink limestone with olive green argillaceous limestones and greenish shales intercalated. In Swindale Beck the grey limestones are sparsely fossiliferous, though the argillaceous limestones contain abundant fossils. In the Keisley Block the grey, pink and white limestones are often crystalline and very fossiliferous. The fauna, which is of great interest, has been made the subject of a paper by Mr. Cowper Reed (see list and

references at end). The limestones are of Lower Ashgillian age. Considerable attention will be paid to the development of the limestones in the Keisley Quarries.

(6) *Ashgill Shales.*—Leaden grey shales of Upper Ashgillian age succeed the Keisley Limestone of Swindale. They contain the characteristic *Strophomena* (?) *siluriana* and *Phacops* (*Dalmannites*) *mucronatus.* They form the highest Ordovician strata of the area.

(7) *Lower Stockdale Shales (Skelgill Beds).*—The relationship between the highest Ordovician and the lowest Silurian strata is nowhere shown in the inlier, as a fault always separates them. In the adjacent Lake District the Skelgill Beds succeed the Ashgill Shales with perfect conformity.

These Skelgill beds in the inlier are found in three or four isolated patches. The most interesting is a very poor exposure of the lowest zone but one (the *Dimorphograptus confertus*-zone) faulted against the Keisley limestone of Keisley, and one of the succeeding zone (of *Monograptus fimbriatus*) in Great Rundale Beck. In each case the beds are dark grey to black Graptolite shales.

(8) *Upper Stockdale Shales* (*Browgill Beds*).—These are best exhibited in Swindale Beck, where they are separated from the Ashgill Shales by a fault. Two zones occur here, the lower of *Monograptus turriculatus*, the upper of *Monograptus crispus*, but fossils are now difficult to obtain. The beds are pale green and grey mudstone and fine grits, with darker seams containing the Graptolites. The Skelgill beds are of Llandovery age, and the Browgill beds are the equivalent of the Tarannon Shales.

(9) *Brathay Flags.*—The Brathay Flags are greyish shales with a few Graptolites of Wenlock age. They are seen in Swindale Beck and near Harbour Flat. These are the highest Silurian beds near Appleby, though a patch of Coniston Grit of Lower Ludlow age occurs at the most northerly point of the inlier in a stream below the Alston Moor Road.

III.—THE OLD RED SANDSTONE PERIOD.

A period of upheaval followed the deposition of the Lower Palæozoic rocks. At this time the older rocks were folded, faulted, and cleaved. The great movement of the Middle Pennine fault now occurred, and the cross-faults breaking the rocks of the west part of the inlier into blocks were produced, along with many others. At the same time great denudation occurred. Between 20,000 and 30,000 feet of rock must have been removed where the lowest Upper Palæozoic rocks rest on low members of the Skiddaw Slate Series.

These changes took place while the Old Red Sandstone was deposited in Scotland. Around the borders of the Lake District the basal Carboniferous rocks, as a rule, rest with marked unconformity upon the upturned and eroded edges of the Lower Palæozoic formations, transgressing from the Upper Ludlow Rocks of the Tebay district to the Lower Skiddaw Slates of the Skiddaw region. This unconformity in our area is seen near Melmerby, and still more clearly on Roman Fell.

In both of these localities, below the rocks which are universally referred to the Carboniferous, are discontinuous developments of a polygenetic conglomerate—a rock consisting of pebbles of divers character derived from many kinds of rock. I am inclined to refer this to the Upper Old Red Sandstone, and not to the Carboniferous, and there is some evidence of important changes having occurred between its deposition and the formation of the overlying Carboniferous rocks. It consists of a somewhat incoherent reddish sandstone matrix with pebbles of various sizes, derived not only from the local Lower Palæozoic rocks, but from gneisses and schists of distant regions. Much movement has taken place since the formation of the conglomerate, and the pebbles are often striated, indented, bent and faulted.

IV.—THE CARBONIFEROUS PERIOD.

Our attention will be chiefly devoted to the rocks on the east side of the Lower Palæozoic inlier, where they are developed in the great scarp of the Cross Fell Chain.

Above the polygenetic conglomerate of Roman Fell is a massive rock of much greater hardness, consisting of a yellow, grey or red sandstone with small rounded pebbles largely of vein-quartz, and thus markedly contrasted with the pebbles of the polygenetic conglomerate. This forms the great mural scarp of the summit of Roman Fell, and the beds are bent sharply down to a stream on the east side of the Fell, where they are succeeded by sandstones associated with a fossiliferous limestone.

Above this series comes the most important limestone of the district, the Melmerby Scar Limestone, whose white cliffs are on a clear day readily seen from a distance, running along the lower part of the great scarp for many miles. The Melmerby Scar Limestone is the degenerate equivalent of the Lower Scar Limestone of the Yorkshire dales. Above it, other limestones, with some sandstones and shales, occur tier above tier on the face of the scarp, until at last the Millstone Grit is seen forming the summit of the highest point of the chain—Cross Fell (2,929 feet).

The occurrence of an inlier of Millstone Grit close to Appleby, surrounded by rocks of New Red Sandstone age is of interest, as bearing on the sequence of these newer rocks.

The palæontological divisions of the Carboniferous rocks of the Cross Fell scarp are now being worked out in detail by Prof. Garwood, and as we shall not examine the whole series further description here is unnecessary.

V.—THE NEW RED SANDSTONE ROCKS.

These rocks belong to the Permian and Triassic systems, but as they were evidently formed under very similar conditions in this area, we may consider them under the head of New Red Sandstone. Their general dip is in an easterly direction, and accordingly the oldest beds run on the whole to the west of Edenside, the newer on the east, but along part of the Roman Fell tract the oldest rocks are brought up by a sharp bend against the outer Pennine fault.

(A) PERMIAN ROCKS.—It is well known that a great period of elevation and denudation occurred after the deposition of the Coal Measures, and before the accumulation of the lowest Permian rocks of the north of England, and that the latter accordingly rest discordantly on the former. This unconformity is not readily seen in our district, owing to faulting and the obscuring mantle of drift. Just west of Appleby, however, the Permian rocks rest on different members of the Lower Carboniferous, and this appears to be for a short distance an unfaulted junction. Unconformity is, however, shown by the abundance of Mountain Limestone pebbles in the basal Permian rocks, indicating that the Upper Carboniferous beds had been at that time removed by denudation.

(1) *Penrith Sandstone with Brockrams.*—In the Penrith district the lowest Permian rocks are the well-known Penrith Sandstones. As these are traced southwards towards Appleby, thin bands of breccia occur. These breccias are locally known as brockrams, and consist of angular fragments chiefly composed of Carboniferous Limestone, in a matrix of sandstone resembling the ordinary Penrith Sandstones. The limestone fragments are often more or less dolomitised. Around Appleby two important developments of brockram occur, one at the base and the other near the summit, and accordingly the series is there subdivided into:

Upper Penrith Sandstone,
Upper Brockram,
Lower Penrith Sandstone (middle sandstone),
Lower Brockram.

The brockrams vary much in character; in some cases there is much matrix, while in others the fragments are so numerous that the rock might at first be taken for actual Carboniferous Limestone.

The Lower Brockram is well seen in Burrells Quarry, south of Appleby, where the fragments are large and numerous. The rock here is remarkably evenly jointed. The same rock is brought to the surface by a fault to the east of Appleby, and is seen on the road to Dufton.

The Lower Penrith Sandstone is well seen on the road at Appleby, east of the Eden, just south of the Court House, where it exhibits very marked false bedding, inclined on the whole from east to west, and suggesting a westerly travel of the materials.

The Penrith sandstone is usually of a brick red colour: the grains consist chiefly of quartz, with a certain amount of decomposed felspar. The grains are frequently markedly rounded, presenting a "millet-seed" appearance, though in many cases they have received a secondary deposit of silica, giving rise to the well-known crystalline sandstones. The absence of the detrital mica is significant, and affords a ready means of distinguishing the Penrith and St. Bees' Sandstones.

The Upper Brockram is in general respects similar to the lower breccia. It is seen, among other places, in Hilton Beck. Prof. P. F. Kendall has shown that, although the fragments, like those of the Lower Brockram, are largely derived from the Carboniferous Limestones, there is also a fair proportion of older rocks, such as conglomerate, vein-quartz and rhyolite. He argues that the basal Carboniferous beds which were covered during the formation of the Lower Brockram, had now become exposed by denudation, and suggests that movement occurred along the Pennine fault between the formation of the two brockrams ; if the thickness of the Penrith Sandstones group be taken at 1,000 ft. (the thickness is very difficult to estimate) he argues for a movement along the fault to that amount.

The Upper Penrith Sandstones on the whole resemble the sandstones between the brockrams. They may be seen on the road to Dufton, and also in Hilton Beck.

(2) *Hilton Shales, Magnesian Limestone, &c.*—Above the Penrith Sandstone group comes a variable group of grey and yellow sandy shales, gypseous shales, and impure magnesian limestones and sandstones, known as the Hilton Shales, being well exposed in the beck of that name. The group is of interest on account of the occurrence of plants, first discovered by Prof. Harkness. The following have been recorded:—*Alethopteris goepperti*, *Cardiocarpum triangulare*, *Odontopteris* sp. *Sphenopteris dichotoma*, *S. Naumanni*, *Ullmannia selaginoides* and *U. Bronni*, a flora known in the German Kupferschiefer.

It is very difficult at the present day to secure good specimens from the Hilton exposure.

(B) TRIASSIC ROCKS.—The plant beds are succeeded by a series of gypseous red shales, which are taken as the basal deposits of the Triassic rocks. Mr. Goodchild gives a figure in the Survey Memoir of these shales resting unconformably upon the plant beds near Newbiggin, some way north of Appleby. They appear to pass up into the St. Bees' Sandstone, of which indeed they may be regarded as the base.

The St. Bees' Sandstone is well bedded; of a more purple red than the Penrith Sandstone; it contains thin inconstant "wayboards" of red shale, often shows discolouration patches, is rarely crystalline, and above all contains a fair amount of detrital mica. Many good exposures of the rocks of this division are seen, as it is extensively quarried for building purposes. There are large quarries just west of the village of Dufton, and others by the side of Hilton Beck, as one approaches the village of Hilton. Mr. W. Brockbank records plants at two horizons at Hilton Beck. See list of References, pp. 147, 148.

There are no newer rocks near Appleby, though the St. Bees' Sandstone around Carlisle is succeeded by higher Triassic rocks, and ultimately by Liassic rocks still preserved in an outlier.

VI.—INTRUSIVE IGNEOUS ROCKS.

Many igneous dykes and small bosses are found among the Lower Palæozoic rocks, belonging principally to the groups of the quartz-porphyries and lamprophyres. The most interesting are the mass of quartz porphyry on the western flank of Dufton Pike, often termed the "Dufton granite," which is remarkable for the large plates of mica, and the lamprophyres of Swindale Beck. One of these contains rare phenocrysts of orthoclase resembling the well known porphyritic crystals of the Shap granite. Mr. Harker and I have given reasons for supposing that this group of dykes are apophyses of that granite, in which case they are of Devonian age.

A later intrusion is the well-known Whin Sill, which runs for miles, at slightly different horizons, among the lower Carboniferous rocks of the great Pennine scarp. It will be seen around High Cup Gill. The rock is a diabase, consisting of plagioclase felspar, augite, and an iron ore. In the Appleby District, where it is thin as compared with the development on the east side of the Pennines, it is a fine-grained rock, and the amount of metamorphism which it produces on the rocks with which it is in contact is less than that produced to the east in the well-known section at Falcon Clints, in Upper Teesdale.

A day has been set apart for visiting the Shap granite, for, as already mentioned, the granite is connected with the Appleby District, as its apophyses extend into the rocks of the inlier. The visit to Shap will enable us to see the western limb of the great earth-wave whose trough is in Edenside.

The granite itself is intrusive in rocks of the Borrowdale Volcanic Group. It forms a mass about 1½ miles along its greatest diameter, being a rough ellipse approximating to the circular form.

The granite, save when stained red, has a grey matrix of orthoclase and some plagioclase felspar, quartz and biotite. A noticeable point is that the quartz crystallised before the orthoclase. In this matrix are embedded large pink orthoclase crystals sometimes two inches in length. The abundance of dark inclusions is of interest; some are fragments of other rock which have been caught up in the granite, but many are more basic varieties of the rock itself, marked by the possession of biotite, plagioclase and sphene. These basic patches contain the large orthoclase phenocrysts, which are usually corroded, and have an altered margin of plagioclase and quartz. They are closely related in character to the lamprophyric apophyses.

The apophyses occur as dykes and sills, chiefly radiating from the granite, and extending to distances of over 12 miles from the mass, though they are most abundant near that mass, where they frequently contain orthoclase phenocrysts. The dyke rocks are of two kinds, lamprophyres and quartz porphyries, the former being more basic and the latter more acid than the granite itself. The phenocrysts in the lamprophyres are rounded and corroded, with plagioclase margins like those of the basic patches in the granite.

The aureole of metamorphism extends to a distance of about three-fourths of a mile from the granite margin. A great variety of rocks has undergone metamorphism, including basic, intermediate and acid lavas and ashes, impure limestones, shales and grits, and also a metalliferous vein.

The lavas and ashes had undergone weathering before metamorphism. The alteration of the intermediate and basic rocks presents points of interest. Near the granite margin the rocks are completely re-crystallised, with formation of water-clear felspar and a purple-brown mica. The vesicles of the lava were filled with amygdaloidal substance before alteration. This has been converted into crystalline calcite, fibrous amphibole, epidote, garnet and other minerals. Similar changes have taken place in the metalliferous vein.

The impure limestones are changed into lime-silicate rock, with development of various minerals such as lime-garnet and plagioclase.

The other rocks have undergone various changes according to their composition, but as the time will be too limited to examine these in detail, it is unnecessary to particularise them here.

VII.—GLACIAL PHENOMENA.

In the limited tract of ground which we shall traverse, it is not probable that we shall come across any glacial striæ, and the direction of travel of the ice is indicated mainly by the distribution of the boulders, and to some extent by the conformation of the ground. The striæ which have been observed in the district, and the distribution of the principal boulders is shown in the map by the late J. G. Goodchild, here reproduced on Plate III.

The principal glacial accumulations are till, with some intercalated sands and gravels, and local moraines.

The till is widely spread over the lowlands of Edenside. Its surface is not level, but presents whale-backed ridges or drumlins with intervening hollows. These drumlins have a general direction of S. 30° E., as noted by Mr. Tiddeman. Otherwise the till is of an ordinary character. An interesting section is seen in a quarry of St. Bees' Sandstone near Hilton Beck, where in one place the till has been forced for a distance of about 6 feet below a projecting hard bed of the sandstone. The sands and gravels associated with the till were probably formed in more than one way. Mr. Tiddeman records the finding of a tooth of ox, probably bison, in clean sand and gravel below the boulder-clay at Appleby.

Local moraines occur at the ends of some of the valleys entering Edenside from the Pennine Chain. The most prominent are at the end of the High Cup valley, and at Cosca, near the mouth of Great Rundale Beck.

The most interesting boulders are those of Galloway, with which must be classed the Carrock Fell gabbros, and the Ennerdale granophyre which have come from the north-west; and of the Shap granite which have come from the west and south-west. Both sets of boulders ultimately pass over Stainmoor Pass, on the east of the upper end of the Edenside lowlands.

The passage of the boulders over this pass is of great interest. The Shap granite boulders are not found passing over the lowest part of the pass where the high road and railway crosses the Pennine watershed. There are, in fact, three belts of distribution of boulders among the low ground in the vicinity of the actual pass. These belts run approximately east and west. The most southerly occupies the lowest ground of the pass, and contains boulders which have probably been brought from the high ground surrounding the head of the Eden valley. The middle belt contains boulders of Shap granite, but none of the Galloway rocks, while the northernmost belt has a mixture of boulders of Shap and Galloway rocks. The Shap boulders are found in places at a slightly higher elevation than is attained by any of the parent rock.

In addition to these boulders, fragments of Brockram have also been carried over Stainmoor. The highest point where these rocks occur *in sitû* is nearly 700 ft. below the point where they cross the watershed. These boulders, therefore, have travelled up hill to the extent of 700 ft. vertical, within a distance of four or five miles.

A full account of the travel of boulders in this district will be found in the late Mr. Goodchild's well-known paper on the "Glacial Phenomena of the Eden Valley," for which a reference is given in the list of works at the end of this paper.

VIII.—PHYSIOGRAPHY.

The lowland tract of Edenside is clearly "tectonic" as regards origin, due to the letting down by the Pennine fault of the softer New Red Sandstone strata between the Palæozoic rocks of Lakeland to the west and of the Pennines to the east. The present features, however, are no doubt directly due to denudation. As the general trend of the strata, and of the strip of Lower Palæozoic rocks is on the whole a little east of south, the trend of the major features is in the same direction. The most prominent of these features is undoubtedly the great Pennine scarp, determined initially by the apposition of soft rocks to hard produced by the outer Pennine fault.

Considerable modification has taken place in details. To the east of the inner Pennine fault, the scarp runs fairly regularly, save where indented by consequent streams flowing westward from the Pennine watershed. The scarp itself is diversified by gentler slopes, due to shales, and steep slopes and scars caused by the basal conglomerates and sandstones of the Carboniferous, the higher limestones and sandstones, and by the Whin Sill.

The inner Pennine fault is itself sometimes marked by a depression, as, for instance, the col between Brownber and the Carboniferous range to the east, and a similar col between Murton Pike and the same ridge. The Lower Palæozoic rocks form high ground, though never rising to the height of the main elevation of the Pennine watershed. The Skiddaw slates between the middle and inner faults are usually marked by fairly steep vegetation-clad slopes, though where grits, ashes, and dominant quartz veins exist, they form hills, such as Burney, Brownber, and Murton Pike. The latter is bounded by faults on four sides, and so presents the form of a pyramid on a quadrangular base.

The middle Pennine fault is marked by a depression along the greater part of its length. This is well seen between Dufton Pike and Brownber. The Lower Palæozoic rocks between the middle and outer Pennine faults, also rise into pikes in many places, such as Knock Pike, Dufton Pike, Gregory and Keisley Bank. These are composed either entirely of rhyolite, or, in the case of the last-named, of rhyolite and limestone. These pikes also are, in most cases, bounded by faults.

The pikes sometimes show the concave curve of water erosion, as Murton Pike and Dufton Pike, while the summits frequently have the convex curve of weathering beneath vegetation, well shown on Knock Pike. The importance of bounding divisional planes as opposed to rock structure is well exemplified in the case of Dufton and Murton Pikes, of remarkably similar appearance, though the former is composed of rhyolite and the latter of Skiddaw Slates.

Roman Fell exhibits two types of scenery. It lies between the inner and outer Pennine faults. The lower part is Lower Palæozoic rock, and has slopes similar to that of Murton Pike. But though the Carboniferous rocks which once overlay the summit of Murton Pike have been removed, they still occur on Roman Fell, and give rise to the great mural scarp of conglomerate which has already been noticed as capping that fell. The middle Pennine fault here passes beneath this scarp, without displacing its rocks, showing its pre-Carboniferous age along this part of its course, though it would seem that subsequent movement has occurred in post-Carboniferous time along a more northerly part of its course, to the south of Melmerby.

Coming now to the New Red Sandstone rocks of Edenside, we have already remarked that they produce lowland as contrasted with the elevated ground to the east and west; but there is considerable diversity of character in this lowland. The Brockrams and Penrith Sandstones form on the whole comparatively elevated ground for this lowland, with the escarpment facing W. and the dip slope E. The softer plant beds and accompanying deposits form a depression, to the east of which is the scarp-slope of the St. Bees' Sandstone, usually rising to the higher ground on the west side of the outer Pennine fault. The character of the surface of Edenside is, as before observed, considerably modified by the drumlins.

West of Edenside the Carboniferous type of country is again developed, though the ground is generally lower than that of the Pennine scarp. This Carboniferous country ends to the west with a prominent scarp at Shap facing the Lower Palæozoic country of Lakeland.

Another interesting physiographical study is connected with the river courses.

The main drainage of the district is conducted by streams which were initiated on the axis of uplift of the Pennine Chain which produced the primary watershed of the area. They flowed in the direction of the dip, to the east and west respectively. The westerly flowing streams became tributaries of the Eden initiated in the trough of the syncline, and accordingly flowing as a strike-stream in the direction of the axis of that syncline. Few of the dip-streams, however, now flow directly from the watershed to the Eden, owing to capture of the headwaters of the less important dip-streams by the tributaries of the more important, working along lines of weakness, whether faults or soft deposits. The principal captures have been brought about along the line of the Middle Pennine fault, *e.g.*, Great Rundale, flowing behind Dufton Pike to Swindale; or along the line of the Outer Pennine fault, *e.g.*, Swindale Beck into Mill Beck; or again along the strike of the Permian plant beds and their associated soft rocks, *e.g.*, Murton Beck by Frith Beck into Mill Beck. These are but a few examples of many diversions, some of which were probably helped by glacial interference.

The next feature of interest is due to the asymmetrical nature of the uplift. The area may be regarded as exhibiting an asymmetrical earth-fold, having a gentle trough limb to the west, sloping eastward, a steep septum or middle limb sloping westward, and a gentle arch-limb sloping eastward from the summit of the Pennine Chain. This was complicated by the Pennine faults, but, nevertheless, the geological centre of the fold which initiated the drainage from the top of the Pennine Chain is marked by the position at the surface of the Lower Palæozoic rocks. The "law of uneven slopes" has caused a modification of the initial drainage. As the western slope is much steeper than the eastern, denudation has proceeded more rapidly on the west side of the Pennines than on the east side. This is, firstly, the case with the general weathering and transport of the weathered materials by inconstant runnels, and hence the main line of watershed, though parallel with the one of uplift beneath the Lower Palæozoic rocks, now lies to the east of it. Secondly, the law of unequal slopes has caused still greater difference between the erosion of the westerly and easterly flowing streams, and the former are engaged in cutting notches through the watershed towards the east.

The most interesting example of this is presented by High Cup Gill, of which the head is now some distance east of the main line of watershed. This gill is at present engaged in capturing for its tributaries the small streams which once drained into the Tees by a tributary running in the actual line of High Cup Gill, but in the contrary direction. Part of this tributary of the Tees still exists unmodified due east of the head of High Cup (High Cup Nick) and flows over the Tyne Bottom Limestone, and the relic of the floor of this tributary is clearly traceable on either side of the upper portion of the High Cup valley, which now terminates in a very typical cirque, of which the semicircular cliff is formed by the Whin Sill and Tyne Bottom Limestone which here rests upon it.

The Eden has by no means established its base level along the upper parts of its course, and has been in geologically recent times rejuvenated, as shown by the incised meanders along a portion of its course. One of these is responsible for the existence of Appleby. A loop of the river causes a tongue of high ground, on the high narrow neck of which the Castle is built, while the houses of the citizens extend down the slope from the castle towards and on to the alluvial tract of the river. (See Fig. 15).

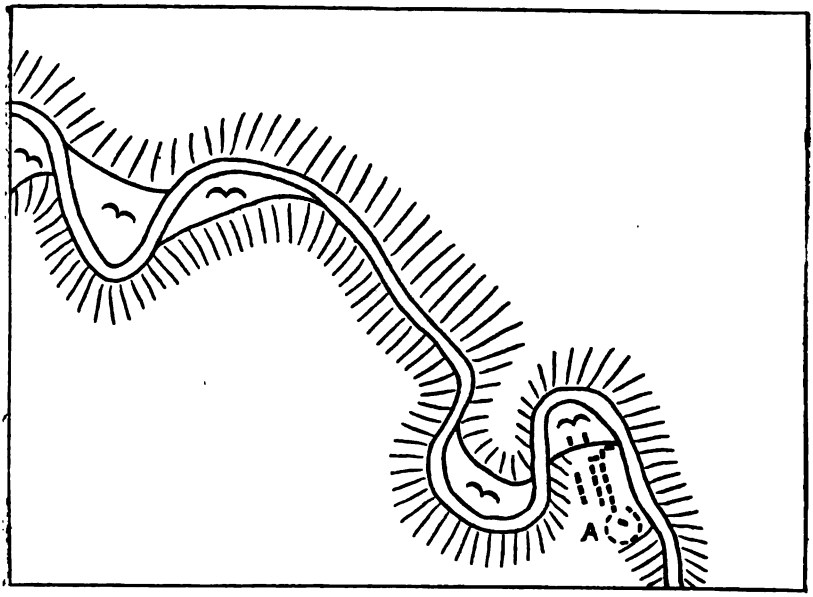

Fig. 15.—Sketch Map of a Portion of the Course of the River Eden.
—*J. E. Marr.*

Scale 6 inches = 1 mile.

A is the town of Appleby. The tracts of Alluvium are marked with the usual sign. The rest is rock chiefly drift-covered.

In addition to the incised meanders, there are hanging valleys connected with the tributaries flowing into the Eden from the east. Most of these, it is true, are more or less graded on those parts of their courses which traverse the New Red Sandstone Rocks, and only "hang" above the outer Pennine fault, but one valley, that of Croglin Water, some miles north of Appleby, plunges down cascades and waterfalls immediately above its junction with the Eden, giving rise to the picturesque features of Nunnery Walks. The position of the hanging valley is here determined by a fairly hard mass of Penrith Sandstone.

Since the period of rejuvenescence, a sufficient period has elapsed for temporary base-levelling of the Eden at Appleby, and accordingly, owing to lateral erosion, tongues of alluvium have been formed alternately on either side of the stream, as shown in the figure.

The encroachment of High Cup Gill on the Tees drainage has been noticed as an exemplification of the law of unequal slopes. But there is a yet more important cause of modifications of the original Eden drainage which may now be considered.

The soft New Red Sandstone rock, over which the Eden runs for the greater part of its course, allowed the river rapidly to corrode after its initiation, and accordingly we find that the town of Kirkby Stephen, where the southern termination of the New Red deposits is situated, but seven miles from the river-head, is less than 600 ft. above sea-level. We must go many miles farther down the adjoining Rivers Tees, Swale, Ure, and Lune before we cross the 600-ft. contour-line, for these rivers run for long distances over rocks of a harder nature than that of the New Red Sandstone. Accordingly the tributaries of the higher parts of the Eden have a steeper grade than those of the rivers mentioned, and therefore tend to extend their heads backwards and so to capture the headwaters of the tributaries of the above-mentioned rivers. In the case of the Swale the capture has proceeded to a slight extent only, but it is more marked in the case of the Tees, Ure, and Lune. One effect of capture is the production of what may be termed "fish-hooks." A tributary, say, of an easterly flowing river, has itself a general easterly trend. When captured by a westerly flowing river the water bends round in a fish-hook curve. Thus the Balder, a tributary of the Tees, appears once to have arisen on Warton Fell, about five miles W.N.W. of its present source. It has been captured by two streams, Swindale Beck (one of many Swindales in this district) and Augill Beck, flowing past Brough into the Eden, with the formation of a fish-hook at each point of capture.

A similar feature occurs at the head of the Eden, where Hell Gill Beck flows west of south for about three miles as though to join the Ure. The upper part is of the nature of a hanging valley, and descends by Hell Gill Bridge to join the northerly-flowing Eden, again forming a fish-hook.

But the most interesting case of capture is seen in the case of the head waters of the Lune at Ravenstonedale. It is proposed to devote a day to this tract, and a somewhat fuller description is necessary.

Ravenstonedale is a horseshoe-shaped depression among the mountains to the south-west of Kirkby Stephen, apparently the head of a valley which extends west to Tebay, where the waters turn south to flow through the gorge of the Howgill Fells, as the River Lune. Standing on an eminence near the village of Ravenstonedale the horseshoe seems to be surrounded by hills. To the south are the Howgill Fells and Wild Boar Fell; to the east the ridge from Wild Boar Fell to Ash Fell; and to the north Crosby Garret Fell and Grange Scar. So obviously does the tract within this horseshoe seem to belong to the Lune drainage that it is almost with a shock that we find the drainage of a con-

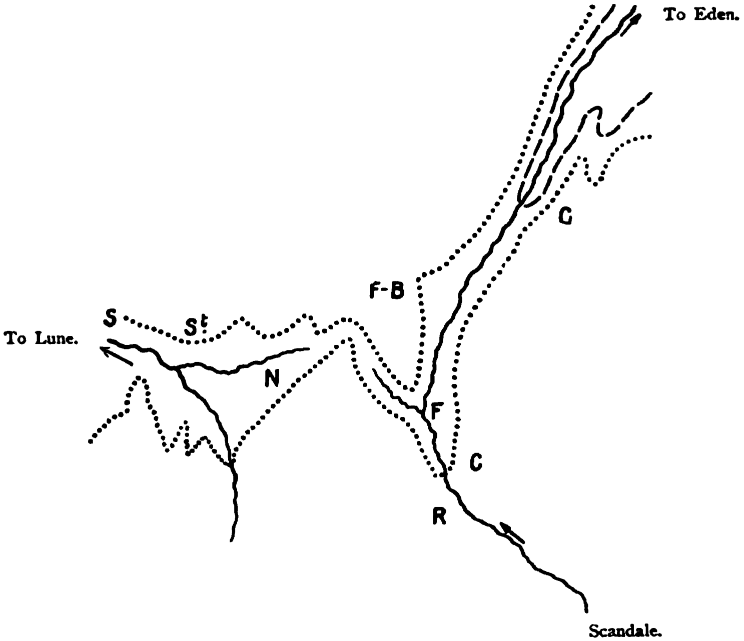

FIG. 16.—SKETCH MAP OF A PORTION OF THE RIVER DRAINAGE IN RAVENSTONEDALE.—*J. E. Marr.*

Scale 1 inch = 1 mile.

C. Coldbeck. F. "Fish-hook." F.B. Friar Bottom. G. Gorge.
N. Newbiggin. R. Ravenstonedale Village. St. Ravenstonedale Station.
S. Sandwath Beck.

The broken line is the 700 ft. contour, the dotted line the 800 ft. contour. The other contour lines are not shown.

siderable tract of country west of Wild Boar Fell and its northerly ridge, which collects to form Scandale Beck, flowing through a cañon-like gorge, through which runs the railway between Ravenstonedale and Smardale stations to fall into the Eden near Soulby, at a height of nearly 500 ft. above sea-level. Now, the 500-ft. contour-line is not crossed on the Lune until we reach High Borrow Bridge, many miles away, and it seems clear that the Scandale stream once starting from the top of the ridge around the horseshoe near the present Smardale station has cut backwards and captured the former source of the Lune.

In connection with this a very interesting physiographical feature near Newbiggin (a village close to Ravenstonedale station) may now be noticed. (See Fig. 16.) South of Ravenstonedale station a small stream, Sandwath Beck, flows westward to join the Lune, through an alluvial flat, at a height of a little under 800 ft. To the east of this a meandering depression will be seen on the ordnance map with its bottom always below 800 ft. Let us follow this. Walking at first from Newbiggin to the N.E., we find a little runnel which rises near the Farm of Friar Bottom, flowing on a well-graded bed to join the Lune. At Friar Bottom we find to our surprise that though in this meandering valley we are on the watershed between the Lune and Eden: from here the winding valley goes to the south-east, and soon a stream rises from a "keld" and flows over a fairly steep but well-graded bed to join Scandale Beck (the tributary of the Eden) north of Coldbeck; where it forms a "fish-hook." One explanation is that this meandering valley was the route taken by the former headwaters of Scandale to join the river Lune, but that on the capture of Scandale Beck by the Eden tributary, a wind-gap was formed. If the water which rises at the keld extends backward, Sandwath Beck will be similarly captured in the future. Unfortunately there is much drift about here, and although the northern bank of the meandering valley is formed of limestone, the southern bank is occupied by glacial materials, and it may perhaps be claimed by glacialists that we have a case of a glacial-lake overflow. However this may be, the actual capture and formation of the Smardale gorge seems to me to be entirely unconnected with glaciation. (See Fig. 16.)

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ORDINARY MEETING.

FRIDAY, JUNE 7TH, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association: Robert George Baird, Victor Gollancz, L. F. Maxwell, Arthur Rust.

The President announced that the arrangements for handing over the Library to University College were now completed, and that the University of London had passed the following resolution: "That the cordial thanks of the Senate be transmitted to the Trustees of the Geologists' Association for their generosity in transferring their Library to the University."

The following paper was read:—"The Chalk of Surrey: Part II, the Western Area," by George W. Young, F.G.S. The paper was illustrated with a series of lantern slides made by Mr. W. P. Young.

The President, in moving a vote of thanks to the author, commented on the interesting nature of the paper and invited discussion, in which Messrs. Newton, Treacher and Dibley joined, and Mr. G. W. Young afterwards replied.

ORDINARY MEETING.

FRIDAY, JULY 5TH, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association: Fred Andrews, Roger Meeson, Herbert A. Rigg, K.C., Rev. Henry Percy Thompson, Miss Marie Vobe.

The following paper was then read:—"The Geology of the Appleby District, Westmoreland," by John Edward Marr, Sc.D., F.R.S., advance copies of which had been printed and were on sale to the members. The paper dealt with the district to be visited during the Long Excursion, and was illustrated with a fine series of lantern views, most of which were contributed by Professor Garwood.

The President moved a vote of thanks to the author, and expressed a hope that all those present would come to Appleby and hear more from Dr. Marr in the field about the interesting problems which he had discussed in the paper. He also alluded to Professor Garwood's beautiful Photographs. Mr. Whitaker and Professor Garwood then spoke, and Dr. Marr replied.

EXCURSION TO BRISTOL.

WHITSUNTIDE, 1907.

Directors : PROF. S. H. REYNOLDS, M.A., F.G.S., A. VAUGHAN, B.A., D.Sc., F.G.S., PROF. W. S. BOULTON, B.Sc., A.R.C.S., F.G.S., and T. F. SIBLY, B.Sc., F.G.S.

Excursion Secretary : GEORGE W. YOUNG.

(*Report by* THE DIRECTORS.)

THE headquarters were at the St. Vincent Rocks Hotel, Clifton. Most of the members arrived on Friday, May 17th. They were joined on each of the days by many local visitors, bringing the number on each excursion to above 50.

SATURDAY, MAY 18TH.

Director : DR. VAUGHAN.

The members assembled at the fountain at the top of Bridge Valley Road, where they were joined by the Director at 9.30 a.m. Fine weather fortunately presented the beautiful Avon Gorge in its most charming aspect and permitted the full programme to be carried out.

The great fault at the foot of Bridge Valley Road was seen to separate the highest beds (D_2)* of the Carboniferous Limestone, on the north, from the *Seminula* beds on the south. The large heave of the fault was demonstrated by walking southward as far as the base of D_1, and noting the distance covered, on the return traverse, before the same bed was again met with, in the main sequence, north of the fault.

D_2, D_1 and upper S_2 were rapidly passed in review.

S_1 and the base of S_2 were more carefully examined in the Great Quarry, where the abundance of *Seminula ficoides* and of *Lithostrotion martini* immediately arrested the attention. At the top of S_1 the Cyathophylloid *Caninia* (*Caninia cylindrica* mut. S_1) and the spinose semireticulate *Productus* were pointed out; from the lowest beds of S_2 a specimen of *Carcinophyllum* θ was obtained.

Time did not permit of the examination of the *Syringothyris*-zone (C), but attention was drawn to the importance of this period as one of wide-spread movement, only indicated in the Avon by rocks of shallow-water origin.

The *Zaphrentis*-zone (Z) was seen in the Black Rock Quarry, where the abundance of *Zaphrentis* in the upper part (Z_2), and the predominance of Brachiopods in the lower (Z_1) were pointed out. At the top of Z_2 (horizon γ), the first establishment of the Caninoid *Campophylla* and the acme of *Syringothyris cuspidata* were noted; a little below this level occur the celebrated "Clifton Fish Beds."

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* For explanation of terms used see the Table *ante*, *p.* 73.

The main portion of the *Cleistopora*-zone (Lower Limestone Shales of the Avon Section) was passed by without examination, but some time was spent in studying the base (*Modiola* Phase $\equiv$ Km) of the zone, in the railway cuttings, near Cook's Folly, on the two Avonmouth lines. Here, attention was especially drawn to the evidences, both faunal and lithological, of extremely shallow water conditions during the deposition of these beds which immediately succeed the Old Red Sandstone of the Avon section.

Modiola was found plentifully in the shales and *Athyris cf. Roissyi* was collected from the upper cutting. Interest was also shown in the well-known "Bryozoa" and "Palate" beds.

The party went by train from Sea Mills to Shirehampton, where they had luncheon, after which they crossed the river by ferry to Pill, and the return walk was made from Pill to the base of the Carboniferous Limestone, on the Leigh Woods side. In the course of this walk, the Dolomitic Conglomerate was seen lying, unconformably, upon the Old Red Sandstone in the cuttings on the Portishead Railway. The party also collected specimens of Celestite (sulphate of strontia) from stacks which had been brought from the surface workings at Leigh Court, Abbot's Leigh, where the mineral occurs in irregular seams in the Keuper Marl.

Work was then resumed upon the lowest beds of the Avonian sequence in a low riverside exposure. Specimens of *Strepsodus* were obtained from the top of the Old Red Sandstone, and Brachiopods (*Productus bassus*, *Camarotœchia*, etc.) from the lowest beds of K_1, immediately above the Bryozoa Beds.

The lowest beds of the *Zaphrentis*-zone (Horizon β), were searched in Quarry 1 and yielded the Brachiopod assemblage characteristic of that level (*Spirifer clathratus*, *Productus burlingtonensis*, *Spiriferina cf. octoplicata*, *Syringothyris aff. cuspidata*, etc.).

In Quarry 2, the base of Z_2 yielded the early form of *Schizophoria resupinata*, associated with the small progenitors of the papilionaceous *Chonetes*. The uppermost beds of this quarry displayed *Zaphrentis aff. cornucopiæ* at its maximum.

In Quarry 3, the *Caninia*-Oolite is finely displayed, resting upon a fossiliferous band in which *Syringothyris laminosa* is a characteristic form. The ill-developed bedding of the oolite indicates continuity of deposition and the purity of the oolite-structure points to conditions of clear but shallow water.

In Quarry 4 (S_1 and S_2), the same fossils were observed as in the Great Quarry at the corresponding level on the Clifton side. Especial interest was shown in the prevalence of a peculiar calcareous breccia which exhibits pisolitic structure on a large scale.

No further stop was made until the base of D_1 was reached, where the abundance of *Productus giganteus*, *Cyathophyllum murchisoni* and *Dibunophyllum* θ was immediately remarked.

After re-passing the Great Fault, the repetition of the sequence along the side of the towing-path was hurriedly reviewed and the river section finally left at the foot of Rownham Hill, where tea was obtained.

Halfway up this hill a visit was paid to Rownham Quarry where D_2 beds are worked. (This is the level from which the Clifton Corals, so widely-distributed in museums, have almost all been obtained.) The quarry was in a bad state for examination, but most of the characteristic fossils were obtained (*Lonsdalia*, *Lithostrotion portlocki*, *L. ensifer*, *Productus cf. latissimus*, etc.). Attention was directed to the recurrent beds of patchy limestone which weather into rubbly beds.

The Director pointed out that, although these are the highest beds which contain Avonian fossils in the Bristol area, yet they were laid down at an earlier date than the Lower Limestone of Scotland; and that the Millstone Grit of Bristol, at least in its lower part, is the equivalent of the highest subzone of the Avonian (D_3) in the Midlands and north of England.

After recrossing the river by the Suspension Bridge, a brief visit was paid to the uppermost *Seminula*-beds of Observatory Hill. A thick limestone bed, crowded with weathered specimens of *Seminula ficoides*, was examined in order to demonstrate the internal spiral arms. Finally, the party was shown a good example of the peculiar concretionary beds which characterise the top of S_2 in the Bristol district.

The thanks of the Association are heartily rendered to Mr. E. Newton, district superintendent of the Midland Railway, for permission to visit the cuttings on the Avonmouth lines; and to Prof. Wertheimer, Principal of the Merchant Venturers' Technical College, for kindly allowing the party to examine the beds in the Great Quarry.

MONDAY, MAY 20TH, 1907.

EXCURSION TO THE SILURIAN INLIER OF THE EASTERN MENDIPS.

Director: PROF. REYNOLDS.

Leaving Bristol at 9.30 the party, numbering about 50, reached Shepton Mallet at 11.20. There they were joined by Mr. H. B. Woodward, and after some delay, due to insufficient carriage accommodation, started for Beacon Hill, where the coarse, ashy conglomerate is exposed at the Rifle Butts. Firing, however, was going on and rendered a visit to the exposure impossible. The party then proceeded to Sunnyhill Quarry, where the finest section of the Silurian igneous series occurs. The exposure shows a very varied series of tuffs about 100 ft. thick in all, underlying a thick mass of pyroxene andesite. A considerable number of fossils were found in the lower part of the tuff section. Crossing the road to the large and well-known Moon's Hill quarry good specimens of the lava, which here as everywhere else in the district is a pyroxene andesite, were collected. Mr. H. B. Woodward took this opportunity of congratulating the Director on having added the Silurian to the map of Somerset. In the small quarry south of the tunnel a block of tuff was found which may possibly have fallen from an exposure on the quarry face. No tuff has yet been found *in sitû* at Moon's Hill. The party then walked across the fields to the quarry in coarse, ashy conglomerate to the east of Moon's Hill. The Director explained the various suggestions which have been made to account for this curious deposit. The general opinion appeared to be that the rounding of the blocks could only have been accomplished by water action, and certain indications of bedding which were detected in the finer grained material were held to support this view.

The next halt was made at Tadhill, the spot where Silurian fossils were first met with in the Mendips. The rock here is a fine-grained felspathic tuff, and though the trench which afforded a good section of the material had been filled in, many fossils were collected from the loose *dêbris*. Most of the party then walked across the fields to Downhead, where there is a third large quarry in pyroxene andesite, not differing materially from the rock exposed at Moon's Hill and Sunnyhill. Joint planes in this quarry were lined by a peculiar pale, flexible material, which proved on examination to be nearly pure magnesium silicate.

Rejoining the brakes at Downhead, the party drove through the beautiful village of Mells to Frome, where tea was obtained at the Wallbridge Hotel, and returned to Bristol by the 5.50 train. It was hoped that time would have permitted a visit to the Vallis quarries, where the upper beds of the Inferior Oolite rest with strong unconformity on the Carboniferous Limestone, but this was impossible, though a distant view of the quarries was obtained from the carriages.

TUESDAY, MAY 21ST.

Director: MR. T. F. SIBLY.

The party left Bristol by the 9.30 train, and, alighting at Burrington Station, walked to Burrington Combe, where the day's work began. The basal beds of the *Dibunophyllum*-zone, exposed in a quarry at the mouth of the Combe, were first examined. Ascending the Combe, the *Seminula*-zone, which is not well exposed, was passed over, and the next halt was made to examine the upper beds of the *Syringothyris*-zone. The strongly oolitic nature of these beds was noted, and several specimens of *Cyathophyllum* ϕ, a characteristic fossil, were obtained. After a brief examination of the lower *Syringothyris*-beds, some time was devoted to collecting from the highly fossiliferous limestones of Horizon γ. Numerous fossils were obtained, including many specimens of *Caninia cylindrica*, the great abundance of which coral characterises this level.

Continuing the walk up the Combe, the fine escarpment of Z_2 limestones on the south side of the road was noticed. Some members of the party accompanied the Director up a tributary ravine to examine the shales of the lower *Cleistopora*-zone (*Modiola*-phase), and the uppermost beds of the Old Red Sandstone, exposed in the stream-section. Others stayed to collect fossils from the *Zaphrentis*-beds. The attention of members was drawn to the disappearance of the stream in a swallet beside the road.

Joining the brakes, the party drove over the Mendips and down the magnificent Carboniferous Limestone gorge of Cheddar. Time did not permit of an examination of the fossiliferous beds at the base of the *Seminula*-zone, but a halt was made at the quarry lower down the gorge, and fossils were collected from the upper beds of S_1, there exposed. The abundance of *Lithostrotion martini* in these beds was noted.

Arriving at the stalactite caves the party divided into two sections, one of which visited Gough's Cavern and the other Cox's Cavern. A few energetic members found time to see both.

After tea at the Cliff Hotel the party returned to Bristol by the 5.21 train.

WEDNESDAY, MAY 22ND.

Directors : PROF. W. S. BOULTON and PROF. REYNOLDS.

Leaving Bristol at 9.5, the party, strengthened by a contingent from Clevedon, reached Weston at 9.46, finding brakes awaiting them. They then drove round the eastern end of Worle Hill, where a halt was made at the quarries, and Mr. Sibly drew attention to the overfold in the *Seminula* beds due to the reversed fault traversing the hill. Rejoining the brakes, the party drove to Woodspring Priory, whence they walked along the ridge to the most westerly of the four sections of igneous rocks which here occur interbedded in the Carboniferous Limestone series. The section is given in detail on p. 63 of the current volume of the PROCEEDINGS. Some members of the party devoted their attention to the underlying limestone (hor. Z_2), which is one of the richest collecting grounds in the Bristol district. The second and third exposures of the igneous series which lie about half a mile to the east of the first were then visited, and here, though the lava is absent, the tuff is rather thicker than in the western exposure. Much attention was paid to certain sandy bands with peculiar vertical bodies which occur at the top of the igneous series.

Mr. Sibly contributes the following note as to the position of the igneous rocks at Woodspring:

"The horizon of the igneous rocks in the Woodspring ridge can be determined with considerable accuracy, and the following facts are worthy of special mention. In the westernmost exposure, where the volcanic series attains its maximum development, the igneous rocks occur immediately *under* horizon γ. In the easternmost exposure, however, where the igneous series is represented only by a few feet of tuff, this tuff occurs at the *top* of horizon γ, and is immediately overlain by the unproductive "*Laminosa*-dolomites," the basal beds of the *Syringothyris*-zone. The tuff seen in the easternmost exposure must, therefore, be of later date than any part of the volcanic series seen in the westernmost exposure."

From Woodspring the party drove through Kew Stoke to Spring Cove, near the Old Pier, Weston. Professor Boulton described the main features of the basalt lava-flow in the limestone, which is here exposed from the cliffs across the fore-shore to low-water, a distance of about 150 yards. The special features noted were:

(*a*.) The complex character of the flow: the coarse, pillowy structure at the cliff end, with the tuff-like character of the basalt between the spheroids.

(*b*.) The lumps and masses of oolitic limestone (see Plate IV, Fig. 1), now largely converted into dolomite, and in many cases apparently picked up as calcareous mud by the lava and squeezed into spaces between the spheroids of basalt.

(*c*) The agglomeratic character of the middle portion of the flow, with lumps of scoriaceous basalt (see Plate IV, Fig. 2), as well as limestone embedded in a coarse ash, all showing signs of successive outpourings along the calcareous floor of the sea, and not, as at Middle Hope, the deposition of ash to form stratified layers in the limestone.

(*d*) The contact-phenomena at the junction of the limestone below the lava, and the discoloration and dolomitization of the underlying beds.

After tea at Huntly's Restaurant the 6.30 p.m. train was taken for Bristol, and the excursion brought to a close, most of the members returning to London by the 7.24 train from Bristol.

EXCURSION TO PORTISHEAD.

(*Report by* PROF. REYNOLDS.)

During their stay at Bristol some of the members made an unofficial excursion to Portishead. The first spot visited was Fore Hill, where the relation of the Carboniferous Limestone to the Old Red Sandstone is difficult to understand, and several varying interpretations based on faulting have been suggested. The party then proceeded to Battery Point, which is formed of limestone (hor. β). A short distance to the south the *Cleistopora* beds (K), which are finely exposed and very fossiliferous, are thrown into a series of small flexures probably owing to a reversed fault which brings lower beds (hor. α) over them. At this point the party divided, some proceeding *viâ* the limestone quarries of the Portishead and Clevedon road, the others by the coast path which displays a splendid series of unconformities between the Old Red Sandstone and Dolomitic Conglomerate. The two sections reunited at Walton Castle, near Clevedon, and after a visit to Coles' Quarry, where the superficial deposits are of much interest, and a small cave has yielded many bones,* drove back to Bristol.

The President during the course of the excursion took the opportunity of thanking in turn the various Directors for the great interest that the excursion had afforded to the members.

EXPLANATION OF PLATE IV.

FIG. 1.—Mass of oolitic limestone embedded in basalt. The margin of the limestone has been baked by the hot lava. The basalt also shows veins and strings of infiltrated calcareous matter.

FIG. 2.—Spheroids of amygdaloidal basalt embedded in Tuff. The latter has flowed out in a fragmental condition, carrying lumps of basalt with it.

EXCURSION TO THE CUCKMERE VALLEY, SEAFORD AND NEWHAVEN.

SATURDAY, JUNE 1ST, 1907.

Director: J. VINCENT ELSDEN, B.SC., F.G.S.

Excursion Secretary: MARK WILKS,

(*Report by* THE DIRECTOR.)

IN spite of threatening weather, a party of ten met the Excursion Secretary at London Bridge Station and travelled by the 9.45 a.m. train to Berwick Station on the L. B. & S. C. Railway. Here attention was drawn to a section in the railway cutting near the station, where a covering of coarse gravel rests upon Lower Greensand on the 100 ft. contour and more than 70 ft. above the level of the Cuckmere river. A brickyard on the north side of the line is on Weald Clay, so that the junction here is not far from the railway cutting. The examination of this feature, not being included in the day's programme, the party set out along the field path to Selmeston, near which place a sand pit shows some fifteen feet of ferruginous sand in the topmost part of the Lower Greensand. The junction with the Gault was not seen in this pit, but was formerly exposed near the church close by, in a sand-pit now disused. A search was here made for the Gault basement-bed, but without success, as the section was obscured by slips and overgrowth. Clayey sands, possibly from the base of the Gault, were seen in places on the east side of the pit, but on the west side Lower Greensand is alone exposed. This pit has a special interest as being the supposed locality whence Mantell procured from the Gault basement-bed the specimen of *Zamia* (*Pinites*) *Sussexiensis*, described by Mr. Carruthers as unique.[*]

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* Some of these bones were exhibited by Dr. H. C. Male at the conversazione in November last.

Bristow's description of the section formerly exposed here is as follows:

GAULT.	Dark olive-green clayey sand. Grey and ferruginous sand with phosphatic nodules and fossil wood = basement bed. 6 inches.
LOWER GREENSAND.	Greenish-white sand, with green grains, weathering ochreous brown.

The Director called attention to the fact that when he examined this section in 1886 there was exposed a large pocket of coarse gravel, similar to that seen near Berwick railway station. This is figured in a paper published in the *Quarterly Journal of the Geological Society*.[†] These gravel patches are frequently found occupying the higher contours in the southern margin of the Weald, and in this area are almost on the watershed between the valleys of the Cuckmere and the Ouse. They form part of the angular flint drift first described by Murchison,[‡] and similar deposits have been noted on the watersheds of all the river basins of the southern Wealden area. Their precise age and origin remain still somewhat obscure.

The walk was continued along the road towards Alciston, and it was noted that stiff clays, presumably Gault, had been thrown up out of roadside trenches between the "Barley Mow" Inn and the sign-post. The width of the Selbornian outcrop is scarcely more than a mile at this place, and at Alciston the boundary between the Upper Greensand and the Chalk is reached.

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[*] *Geol. Mag.*, vol. iii, p. 541.

[†] J. V. Elsden "On the Superficial Geology of the Southern Portion of the Wealden Area." *Quart. Journ. Geol. Soc.*, vol. xliii, p. 647 (1887).

[‡] *Quart. Journ. Geol. Soc.*, vol. vii, p. 349.

At Alciston some large boulders of greywether sandstone were noted. They are at an altitude of 172 ft. O.D., and their origin will be discussed below.

Rain had so far been falling freely, and the walk from Alciston to Alfriston, along the base of the chalk escarpment, was accomplished under conditions of considerable discomfort, during which the marly character of the surface was disagreeably evident. The absence of hard beds from the Upper Greensand in this locality renders its outcrop much less noticeable from surface contours than is usually the case farther to the west, where a conspicuous terrace exists. It is noteworthy, also, that the hard beds of malmstone reappear in the Upper Greensand at Eastbourne, where they have, in the past, been quarried for building stone for local use.

At Alfriston, after a short halt at the famous "Star" Inn, a visit was paid to the Church, where the Vicar, the Rev. C. Doughty, met the party and very kindly pointed out several features of geological, architectural, and antiquarian interest. The Church is a fine specimen of squared flint architecture. It is a cruciform structure of the 14th century, showing a transition between the Decorated and Perpendicular styles. There are piers and dressings of sandstone from the Eastbourne quarries referred to above. The same stone seems to have furnished the shaft of the old market cross, which is noteworthy as being the only example, except that at Chichester, still remaining in Sussex.

At Alfriston a considerable number of greywethers occur, and are apparently often in their natural positions. Those previously seen at Alciston appear to have been moved for the purpose of forming boundary stones. These greywethers, sarsen or Druid stones, are fairly plentiful either upon or near the chalk in certain localities, and are generally admitted to be relics of Lower Tertiary beds. It is, therefore, especially interesting to determine to what extent they occur *in situ*, and how far they may be taken to indicate the former extension of Tertiary strata. Their present distribution is distinctly sporadic, and their nearest occurrence in any number in this neighbourhood is near Brighton and Falmer. It has been suggested that the Ancient Britons may have regarded these hard sandstones with superstitious veneration, since they employed them largely for temples, sepulchral monuments, altars, and for other purposes. It must not be forgotten, also, that in places where hard stone is scarce they may have been used for various economic purposes, and many have probably been broken up for mending roads. These stones afford a striking example of the close connection which often exists between geology and archæology, for neither science is in a position to draw accurate conclusions as to the significance of the distribution of these stones without the help of the other. If, therefore, it is admitted that the Alfriston boulders, which are often of large size and weigh several tons, are nearly *in situ*, they must be taken to indicate a former considerable extension of the Lower Tertiary beds.*

From Alfriston the party proceeded by the road towards Seaford, along which are several chalk pits, which were only hastily examined. The large quarry beneath the windmill first claimed attention. This shows chalk without flints, in well-marked bands of solid chalk, alternating with soft marly seams. The only fossils found were *Rhynchonella reedensis*, Eth., and a very imperfect *Terebratula*. The quarry is probably in the Middle Chalk, since a little farther along the road flinty chalk crops out by the roadside. Patches of gravel occur here in places, and from their position appear to be terrace gravels of the Cuckmere river. They are about fifty feet above the present river level.

In a dip about half a mile farther on there is a small roadside quarry in flinty chalk, as well as a good exposure in the road-cutting, where well-marked bands of tabular flint are seen. The Director stated that he had previously obtained here the following fossils, which had been kindly determined by Mr. H. A. Allen, of the Geological Survey: *Micraster præcursor*, Rowe, *Cidaris clavigera*, Kœnig, *Cidaris sceptrifera*, Mant., *Echinocorys scutatus*, Leske, *Porosphæra globularis*, Phil., *Porosphæra pileolus*, Lam., *Spondylus spinosus*, Sow. This assemblage scarcely fixes the zone with certainty, but it would seem to indicate a low horizon in the Upper Chalk. It may be incidentally mentioned here that in the Upper Chalk of Alfriston there have been found rhombohedral crystals of calcite of remarkable whiteness and purity, closely resembling Iceland spar, and differing from the yellow columnar variety known popularly as "sugar candy," so often met with in the chalk.

Ascending the hill to Hindover, a fine view is obtained of the whole Cuckmere gorge from the chalk escarpment to the sea, where the river mouth has been strongly deflected by the easterly drift of the shingle. A reference to the physiographical features of this area and the denudation of the Weald had been contemplated here, but rain was again falling, and the time having already been considerably shortened by stress of weather, the party pressed on towards Seaford. Near the cemetery a large quarry in the chalk was passed, and the Director enumerated the following fossils which he had recently obtained from it: *Crania egnabergensis*, Retz, var. *striata*; *Pecten*, sp., *Rhynchonella*, sp., *Ostrea*, sp., *Caryophyllia cylindracea*, Reuss, *Spondylus latus*, Sow., Bryozoa and ossicles of star fish. Mr. Allen had again kindly made the determinations of these fossils. The chalk here is soft and flaky, with many large flints. The exact horizon is not certainly indicated by the above scanty fauna, although the *Actinocamax quadratus*-zone would be suspected from the sequence and strike of the beds in the cliff section near at hand.

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* For details of the occurrence of greywethers in other localities, see Prestwich, *Quart. Journ. Geol. Soc.*, vol. x, pp. 75 *et seq.*; also Whitaker, *ibid.*, vol. xviii, pp. 271 *et seq.*

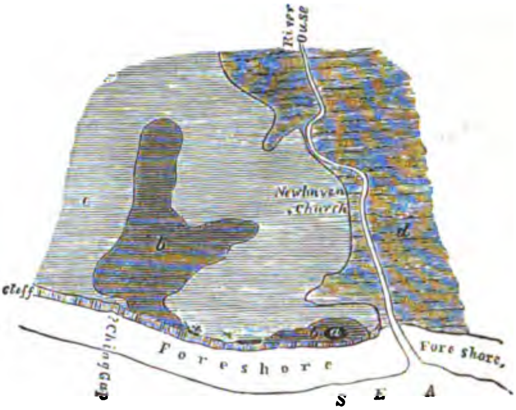

FIG. 17.—GEOLOGICAL MAP OF THE NEWHAVEN OUTLIERS. —*W. Whitaker.*

Scale 1 inch to a mile.

a. London Clay.
b. Woolwich and Reading Beds.
c. Chalk.
d. Alluvium.

× × Between these points the Chalk is capped by a wash of the Tertiary Beds.

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At Seaford, on reaching the golf links, an inspection was made of a sand pit in the Tertiary outlier on the western flank of Seaford Head. Here about 12 ft. of ferruginous sand, with large muscovite flakes, glauconite grains, and some ferruginous concretions, are exposed. These are in the Woolwich and Reading beds, and represent the lower part of the Tertiary series seen at Newhaven. On the cliff the same beds are seen resting on the Chalk, with a concretionary band of flints, sometimes green-coated, at the base. There are no fossils in this exposure. The underlying chalk is in the *Actinocamax quadratus*-zone, as determined by Dr. Rowe, and specimens of *Offaster pillula*, Lam., *Rhynchonella plicatilis*, Sow., *Echinocorys scutatus*, Leske, var. *gibba* occur in it. The state of the tide did not permit of an examination of the *Marsupites*-zone, which is well exposed in the cliff, east of the stone groyne. The strata have a pronounced westerly dip, whereas at Newhaven the bedding is nearly horizontal. The party now proceeded to the railway station and took train to Newhaven Harbour, observing on the way sections of Chalk, capped by flint gravel, and presenting a markedly corroded surface.

Crossing the harbour by the ferry, the ascent of Castle Hill soon brought into view the ancient British earthworks, in which are exposed good sections of the Tertiary outlier, resting upon Chalk of the *Actinocamax quadratus*-zone. The full succession is as follows:

POST TERTIARY.	Coarse red gravel and sand, about 15 ft. thick.
LONDON CLAY.	Clay, about 10 ft. thick, consisting of brownish clays and loams, with a basement-bed, about 1 ft. thick, of sandy clay with flint pebbles.
WOOLWICH AND READING BEDS.	Laminated bluish-grey clays, about 5 ft. thick.
	Shell beds, with oyster bed, passing into shelly clays, about 6 ft. thick.
	Light-coloured sands and clay, about 6 ft. thick.
	Laminated clays and marl, about 10 ft. thick, with thin shell beds.
	Thin beds of sandy clay with lignite, 6 in. thick.
	Bluish clay and marl, weathering brown, with selenite, 12 ft. thick.
	Sand, 20 ft. thick, yellowish-green or mottled.
	Flint breccia, about 2 ft. thick, with green-coated and iron-stained flints, embedded in green sand and often cemented to a hard projecting band.
	Clay, varying in thickness, not more than 1½ ft. containing selenite and Websterite locally.
CHALK.	Chalk of the *Actinocamax quadratus*-zone.

Owing to many slips and falls of the cliff the sequence in this section is difficult to see. Mr. Whitaker's diagram (Fig. 18) shows why later observers have recorded beds higher in the series. The basement bed of the London Clay was first noted by Prestwich in 1854. The junction with the Chalk is especially difficult to examine *in sitû* at all times, and was impossible on this occasion in the slippery state of the cliff after so much rain. It is a ferruginous, flinty conglomerate, somewhat like that seen at Seaford, but containing much selenite, often in large crystals, and also the hydrous sub-sulphate of alumina, known as Websterite, or Aluminite. This occurs in massive form, often tabular, and is dull white in colour, with an earthy fracture. With it is sometimes found friable masses of aluminium hydrate, resembling magnesia in appearance. These minerals result from chemical reactions in the strata, in which the oxidation of pyrites and liberation of sulphuric acid are the primary factors. Aluminium sulphate and selenite are then formed, and the basic salt is probably a result of hydrolysis. Good specimens can often be got from the fragments of conglomerate lying at the base of the cliff. The fossils found in the Woolwich and Reading beds here include *Ostrea bellovacina*, *Melania inquinata*, *Cyrena*, *Cerithium*, *Melanopsis*, *Cypris*, *Unio*, as well as fish teeth and plant remains. The London Clay occupies a very small area on the cliff top in this particular exposure, and on the present occasion was not recognised in the cliff section. It was formerly exposed in the castle moat, now bricked up, and will probably be better seen when the cliff has receded farther.

A thick coating of flint gravel covers the top of the hill at an altitude of about 180 ft. above sea level. This is probably the equivalent of the "Head" or Elephant Bed covering the Brighton raised beach, in which case it would be classified as Coombe Rock, of which there are numerous patches scattered, at various elevations, over the chalk area in this neighbourhood. The term Coombe Rock is of purely local origin, and was first used geologically by Mantell.* The deposits have been described in detail in recent years by Mr. Clement Reid. It is believed by him to have been the result of tundra conditions during the glacial period, when the surface drainage was disturbed by the impermeability of the frozen soil. The stones in this gravel consist largely of angular flints, with some fragments of ironstone, which latter may have been derived from Tertiary beds. It is evidently of tumultuous origin, and its distribution seems to possess but little relation to existing lines of drainage.

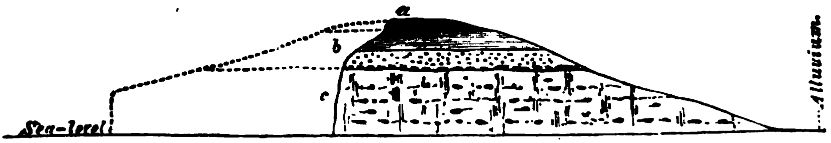

Fig. 18.—Diagram Section of the Cliff a Quarter of a Mile West of Newhaven Harbour.—*W. Whitaker.*

a. London Clay.
b. Woolwich and Reading Beds.
c. Chalk.
Gravel omitted.

The dotted lines show the former continuation of the various beds.

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After passing some time in the examination of the Castle Hill section the party proceeded to the Sheffield Hotel, where tea was provided. The chair was occupied by the President, and, after the customary vote of thanks to the Director, a start was made to the railway station for the return journey to London.

Bad weather greatly marred an excursion which would otherwise have afforded much enjoyment on account not only of the variety of the geological features, but also of the attractive scenery along the route.

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* "Geology of the South-East of England," p. 31 (1833).

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EXCURSION TO CROWBOROUGH.

SATURDAY, JUNE 8TH, 1907.

Director: THE PRESIDENT (R. S. HERRIES, F.G.S.).

Excursion Secretary: A. H. WILLIAMS.

(*Report by* THE DIRECTOR.)

THE members, 18 in number, left London Bridge Station by the 12.25 train, arriving at Crowborough at 2.16. Here they were met by one of the staff of the Crowborough District Water Company, who had been kindly sent by Mr. Middleton, the resident engineer and manager. As there was not time for the party to visit the Waterworks, Mr. Middleton had sent for their inspection the cast of the footprint of a large Iguanodon, which had been discovered some time previously during the progress of excavations there. The footprint was in the roof of the excavation, and had been subsequently cut out and sent to the Brighton Museum. The cast was examined by the members with much interest, and a special vote of thanks was passed to Mr. Middleton for his kindness in sending it for the party to see.

Dr. George Abbott, who was present, had brought some photographs of the footprint, which he kindly exhibited. The party then entered the large brickyard, near the station, belonging to the Crowborough Brick Company, by whose kind permission they were allowed to visit it. This shows a section of whitish sands and clays, with occasional beds of lignite and some clay ironstone. The sandy beds harden into sandstone in places. There are a good many impressions of vegetable matter, and some specimens of *Unio* were noted. This brickyard and the station are situated at the foot and on the east side of Crowborough Beacon Hill, in the hamlet of Jarvisbrook, at a level of about 400 ft. O.D. The Director explained that these beds formed part of the series known as the Ashdown Sands, one of the sub-divisions of the Hastings Sands. He added that all the beds that would be seen that day belonged to that division, so far as could be ascertained. As the top of the hill was approximately 800 ft. O.D., and the beds were nearly horizontal, there being only a slight dip in places, generally away from the hill, it would appear that their thickness must be at least 400 ft. The beds are very similar throughout, sands and sandstones alternating with clay, the former predominating. The series at Crowborough was not capable of sub-division, but probably the lower portions, namely, those at Jarvisbrook and in Crowborough Warren, were the equivalents in time of the so-called Fairlight Clays of the district east of Hastings, though in the Director's opinion these had been separated from the Ashdown Sands on insufficient grounds.

Passing through the brickyard, the party proceeded to ascend the hill towards the golf links on Crowborough Common. Another brickfield about 100 ft. higher than the large one near the station, indicating another clay bed, was briefly inspected, and 150 ft. higher, at about 650 ft. O.D., the members came out on the common, and the fine view to the south was pointed out. From here the South Downs are well seen ending near Eastbourne, and broken by the well-marked gap of the Cuckmere valley and the less obvious one of the Ouse. To the east the high ground about Heathfield could be seen marking another anticlinal axis of these lower Wealden Beds. The party then examined the stone quarry close by, on the east side of the golf links. Here the sandstone is worked in very large blocks which makes a good building stone, and some curious small squares, like setts, of clay ironstone were noticed. There are flaggy partings between the courses of sandstone and one thicker bed of clay. There is an abundance of more or less obscure vegètable remains in the sandstones. A slight dip is seen, its direction being away from the hill, that is to say rather east of south. There are similar workings on the other or west side of the golf links, and at the outlying part of Crowborough, called

White Hill, a little north of the road up which the party had come, and there are other building-stone quarries in the neighbourhood.

Skirting the golf-links the party came out on the main road to Uckfield near the club house, and the Director pointed out the view over Ashdown Forest, a desolate-looking tract of heath-land with occasional clumps of fir trees, stretching away to the west, and forming practically a continuous ridge with Crowborough Beacon. This ridge forms the watershed of the Medway and the Ouse. The streams that feed the former river are deeply cut back into this ridge, and one of the best examples is that which flows through Crowborough Warren. It rises about a mile south of the place where the party were standing, and almost immediately cuts out for itself a narrow valley about 400 ft. deep, round which the ridge of Crowborough Beacon and Ashdown Forest seems to form a sort of semicircle. The Director conducted the party through the Warren down the sides of the valley to the old Mill, where there is a small lake. The members then walked down the valley, passing a little chain of lakes to the new Mill. The scenery is very wild and beautiful, having all the appearance of that of a valley in a mountainous region. A discussion took place as to how such a valley could be formed. The Director had no doubt that it was the effect of sub-aërial denudation, and he thought it was rapidly formed, and in, geologically speaking, comparatively recent times. The puzzle, however, is to account for the power that would excavate such a deep valley in such a short distance from its source. It cannot be accounted for, as in some similar cases, by there having been originally higher ground farther back, because during the period of formation this could not very well have been the case, but the Director pointed out that the character of the strata would lend itself very easily to rapid denudation, both the sand and clay of the Ashdown Sands being easily washed away by the action of water, and the alternations of these beds would be favourable to the formation of springs at various levels. A small section of sandstone was seen at the new Mill, and then the party reascended the hill towards St. John's Church, where there is another sandstone quarry. This showed a section similar to that on the other side of the hill, with the usual alternations of sand, clay and rubbly matter. The dip is slightly to the north, *i.e.*, in the opposite direction to that of the beds on the golf links. A rather curious disarrangement of the beds was seen on the west side of the quarry, which has somewhat the appearance of either a sharp fold or a thrust fault, the upper beds dipping to the north and those below to the south; the upper ones at first sight being apparently bent over so as to be continuous with those below. This apparent disturbance is, however, probably the result of false bedding, as if it had been either a fold or a fault it would have been noticeable before, and it certainly was not, when the Director was at Crowborough two years previously. From this spot a good view was obtained of the Lower Greensand range to the north, and the chief features were pointed out. The party then found their way through Crowborough Cross to the Red Cross Hotel, where tea was provided, there being no time to walk to the summit of the Beacon, 803 ft. After tea, and the usual vote of thanks to the Director, the members proceeded down the hill to the station and returned to London by the 8.25 train.

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EXCURSION TO ALDBURY AND IVINGHOE.

JUNE 15TH, 1907.

Director: H. KIDNER, F.G.S.

Excursion Secretary: T. W. READER.

(*Report by* THE DIRECTOR.)

RAIN fell in torrents during the morning, and only nine members, including the President, gathered at Euston for the 12.20 train to Tring. One member joined later, bringing the number up to ten. On the journey down the weather gradually improved, and on arrival at Tring station the sun was shining. A waggonette in waiting conveyed the party to Aldbury, where the old stocks, with its attached whipping-post, was seen standing in the centre of the village near the pond. The road to the right was ascended past a disused pit in the *Terebratulina*-zone of the Chalk. The face of the pit is covered with scree, and only a few fragments of fossils have been found. Mr. Ashby's brickfield (about 620 ft. O.D.) near Aldbury Common, was next visited. Here was seen a deposit of loamy Brick-earth, very sandy in places, evenly stratified, worked to a depth of 20 ft., but traced to a further 20 ft. below. Here and there in the brick-earth are found small flint pebbles and pieces of angular flint, singly or in pockets. The deposit consists of re-deposited Tertiary material, and rests on chalk of the *Holaster planus*-zone. Its formation occurred probably before the erosion of the existing river valleys in the chalk, and when the escarpment was farther northwards than at present. The erosion and removal of the Tertiary deposits of the area were succeeded by a period of deposition. An accumulation of deposits southward in Glacial times, aided possibly by earth-movement, and the configuration of the chalk surface may have held back streams flowing down the dip-slope, and thus have caused the formation of a lake in which the clays and sands of Tertiary beds to the north brought down by these streams were deposited. Floating roots of trees may have carried and dropped the pebbles and flints. Along the top of the pit was observed a thick, irregular deposit of clay full of angular pieces of flint with some flint pebbles and a very few small ones of quartz. A hole recently dug in one corner had resulted in the discovery of a mass of clay 12 to 14 ft. thick, brilliantly coloured in various shades of purple, red and green. Near the top an oval shaped mass of fine, pale sand was suggestive of its having been thrust into the clay while in a frozen condition. Large flints were found in the lower part of the clay, and extending through the mass in two places were irregularly contorted layers of flint pebbles. Mr. Herries was of opinion that these layers had the appearance of Tertiary pebble beds, their contortion being due to the clay and its contained pebbles having been considerably squeezed by lateral pressure. The clay appeared to consist of one thick mass doubled up, or of two masses pressed against each other, the beds of one part seeming to be horizontal and of the other approximately vertical. Much sand was found amongst the clay, the whole mass being undoubtedly of Reading age, its position and features being in all probability attributable to glacial conditions. The drive was continued through Ringshall, past the Tertiary Outlier mapped by the Survey. The holes dug for sand were examined, but these are much overgrown, and it was impossible to verify by superficial observation whether this is actually an outlier or only re-deposited Tertiary material. After passing Ivinghoe Common it was pointed out that the road was over 800 feet O.D., this being one of the highest parts of the Chilterns. Near Ivinghoe Beacon the conveyance was discharged, the remainder of the way being traversed on foot. On the summit of the Beacon (762 ft. O.D.) a high wind and driving rain spoiled the view, and necessitated a hasty retreat. Nevertheless, the views of Dunstable Downs, of the chalk escarpment towards Wendover, and of the expansive vale of Aylesbury were admired. It was explained that the summit of the hill is above the chalk rock, and in the *Holaster planus* zone. Ivinghoe Beacon was visited by a cycling party under Mr. J. Hopkinson on 23rd May, 1903. In a report of that excursion (*Proceedings Geologists' Association*, Vol. xviii,

p. 171), Mr. Hopkinson says, "They were standing on or just above the Melbourn Rock, which forms the base of the Middle Chalk." The error was obviously a slip, as Mr. Hopkinson knows the district well, and when reporting on an excursion several years earlier he remarked, more correctly, "Chalk Rock caps the hill as an outlier." If it be correct that "Chalk Rock caps the hill," as appears to be the case, then the Melbourn Rock in the adjacent area is at least 250 ft. below the Chalk Rock. This would make the Middle Chalk 250 ft. thick. But the thickness of the Middle Chalk in the district being only about 220 ft., there is a difference of some 30 ft., which can only be explained by the existence of a fault, as suggested by Mr. A. J. Jukes-Browne in the *Memoir of the Geological Survey*. Beacon Hill, being almost entirely grass-clad, makes the point difficult of determination; but that there is such a fault is highly probable. While descending the hill the rain ceased, the remainder of the day being fine, as during the drive.

Near Ivinghoe a pit in the Lower Chalk, *Holaster sub-globosus*-zone, was visited. The "rag" bed referred to in the *Survey Memoir* was examined and seen to be full of green-coated, brown phosphatic nodules. A suggestion that these nodules might have been derived from the Cambridge Greensand is negatived by their being much less phosphatic than the nodules in that deposit, and by the material of which they mainly consist closely resembling the chalk in which the "rag" occurs. The cavities in the nodules in-filled with white chalk have been attributed to boring-molluscs; but their origin is obscure, some being apparently worm-burrows, while Mr. Osborne White stated to the writer that he has reason for believing that some of these cavities are due to sponges. The "rag" is full of fish remains. A tooth was found, and many scales and pieces of bone were seen. *Terebratula semiglobosa* was also found. A local fault in this pit is well shown by the "rag" bed being thrown down to the right, and a slanting streak of crushed chalk in the face of the pit shows clearly the line of fault.

A pit near Pitstone (on the left when returning towards Tring) was interesting on account of the junction of the Lower and Middle Chalk being so well shown. The two Belemnitella marly bands separated by hard white chalk (about 3 ft. in all) were examined. These beds form the top of the Lower Chalk. The characteristic fossil *Actinocamax plenus* and *Ostrea vesicularis* were found by members of the party in these beds, and a specimen of *Rhynchonella* in the chalk below.

The hard, massive, nodular Melbourn Rock, 9 or 10 ft. in thickness, forming the base of the Middle Chalk, was seen conspicuously above the marly bands. In and above the Melbourn Rock several specimens of *Rhynchonella cuvieri*, the zonal index fossil, were found. In the same part of the pit have also been found *Inoceramus mytiloides*, a large example of *Rhynchonella cuvieri*, *Spondylus*, and *Serpula*. The dip of the beds three or four degrees to the S.E., as shown by the Actinocamax (Belemnitella) Marls was noticed, and also the fact that the lower band of grey marl ends off, and apparently becomes merged in the upper buff-coloured band in the middle of the pit, this upper band of buff marl alone being seen dipping to the right in the lower part of the pit.

The party next proceeded to a pit in the *Rhynchonella cuvieri*-zone near "Folly Farm." This pit is full of *Inoceramus mytiloides*, mostly in fragments, but some fairly good, and the zonal index fossil is common. Much loose material and shortness of time precluded careful working, but examples of the index fossil were found. The writer has also found *Conulus* (*Echinoconus*) *sub-rotundus*, *Discoidea dixoni*, *Inoceramus latus* (d'Orb.), *Terebratula biplicata*, *Camerospongia sub-rotunda* (Mant.) and *Ventriculites*.

Thanks are tendered to Mr. E. T. Newton, F.R.S., for identifying some of the fossils. Tea was served at the Royal Hotel, near Tring Station. A vote of thanks to the Director proposed by the President was passed. Thus ended a pleasant excursion which seemed almost impossible at the start in the morning, and the party returned by the 7.18 train to London.

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EXCURSION TO HASTINGS.

SATURDAY, JUNE 22ND, 1907.

Director: W. J. LEWIS ABBOTT, F.G.S., F.R.A.I.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR.)

THE members from London who had started from Cannon Street Station by the 9.16 train were met at St. Leonard's Station by those who had come from various parts of the country, and by the Director, and proceeded at once to 8, Grand Parade, where refreshments were provided by Mrs. Lewis Abbott. Here also the Director had arranged very large collections, more than sufficient for a day's study had the weather turned out unsuitable for outdoor observation. The first contained specimens of the various rocks of the Wealden Series, from the milk-white sandrock composed of transparent quartz grains, at the base of the Ashdown, through all the varieties and bandings of yellows, browns, and brilliant carmines. These sandstones in themselves offer an object of interesting study, showing every description of false-bedding, faulting, and zonal banding, and change of colours from dark browns to brilliant carmines, and even blood reds. The clays are quite as variable, from the white pipe-clays of the Ashdown Series, to the brilliant, mottled Fairlight Clays, where blues and yellows, greys and purples, vie with each other, specimens of the bright mottled-reds, purples and yellows from the Weald Clay found around Pevensey and from Tunbridge being included. The various conditions under which the Entomostraca are preserved were also shown, from the ordinary paper shales, through the iron-stone of the Wadhurst Clay, where the tiny shells are milk-white, and show up upon the dark iron. The tuberculated ones are also well shown in the ferruginous sandstones and in a phosphatized band where the shells are shiny black. The various groups of Mollusca were also pointed out, and a method explained of developing the shells out of the hard limestones by hydrochloric acid. Teeth and bones of many of the vertebrates were also on view, some indicating dinosaurs of great size. Mr. Bailey, of Battle, exhibited a recently-discovered jaw of ***Pholidosaurus***, practically new to this country, from the Purbeck of Darvell Beach Quarry, visited last year by the Association.* Examples of the mode of preservation of the vegetation, from the silicified ***Endogenites*** through the massive lignites to the delicate fern impressions, also called for attention. The curious rock structures known as cat's brains, and pseudobreccias proved of great interest, and examples were also on view of the so-called Wealden flint, and a series to illustrate how the silica segregated out; in the early stages giving rise to the so-called "Hastings granite" ending in a cherty flint.

Another large collection had been arranged to illustrate all the known processes of flint-working as evinced from the features they presented and the conditions under which flint fractured, from the simple cone of percussion to the delicate herring-bone flaking; all the various kinds of "hammers" and "flakers," and a nomenclature of the subject was submitted. All the various processes of nature, the various kinds of thermal fissure, "perletic fissure," "globular fissure," "asphaltic fissure," "starchy fissure," and "prismatic fissure," and examples of the marvellous possibilities of nature of simulating man's works.

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* See *Proc. Geol. Assoc.*, vol. xix, p. 450.

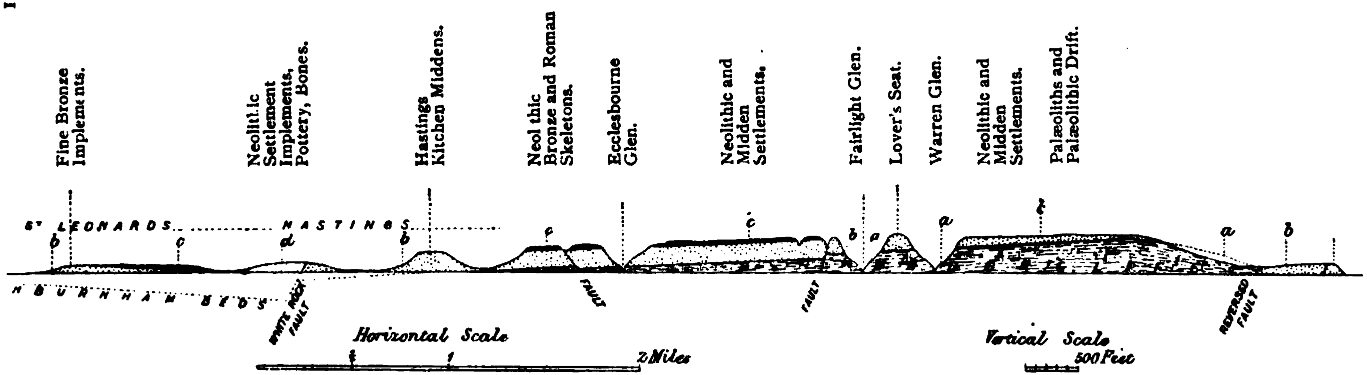
Fine Bronze Implements.
Neolithic Settlement Implements, Pottery, Bones.
Hastings Kitchen Middens.
Neolithic Bronze and Roman Skeletons.
Ecclesbourne Glen.
Neolithic and Midden Settlements.
Fairlight Glen.
Lover's Seat.
Warren Glen.
Neolithic and Midden Settlements.
Palæoliths and Palæolithic Drift.
ST LEONARDS
HASTINGS
BURNHAM BEDS
WHITE ROCK FAULT
FAULT
FAULT
REVERSED FAULT
a
b
c
d
Horizontal Scale
½
1
2 Miles
Vertical Scale
500 Feet

Fig. 19.—Section from Bulverhithe to Cliff End, Fairlight, Hastings.

(After Topley, with descriptions and additions by W. J. L. A.)

The Wadhurst Clay does not occur in the cliffs at St. Leonards.
A small patch occurs beyond the railway.
Ashdown Sands do not extend so far east as shown. East of Lovers' Seat the cliffs are all Fairlight Clays.

a. Fairlight Clays. *b*. Ashdown Sands. *c*. Wadhurst Clay. *d*. Tunbridge Wells Sands.

Also a large series of "implements" of the various kinds of workings, and in various degrees of alteration, patination, etc., which had been manufactured by the Director. The other series illustrated the various implements from the newly discovered site, and the remarkable erratics found associated with them. These latter included volcanic and metamorphic rocks and numerous varieties of purple, red, brown and grey quartzites, Lydites, veined and mottled quartz, chalcedony, ferruginous ironstone and cherts. Some of the latter are spiculiferous and probably radiolarian. Dr. Salter is of the opinion that most of these were similar to those found in the Bunter of Budleigh Salterton. Quartzites and quartzes similar to some of them were shown that had been taken *in sitû* from Wealden beds, and the questions which await answers are: (*a*) have these large pebbles been derived from the Wealden beds? (*b*) have they come from the west, and if so, how? (*c*) were they brought from the east, and if so, when? (*d*) or were they taken there by man? Some of the stones are faceted and very much striated. Some of the cherts are of oolitic origin, and some of the quartzites and the ironstone look like products of the Lower Greensand, but until the rocks have been made an object of special study one cannot say.

The Director called attention to the section (Fig. 19), which although not quite correct would serve the purpose of enabling the members to grasp the main features of the solid geology of the district. It would be evident that Hastings and St. Leonards stood upon a truncated dip slope, the truncation being formed by the cliffs, which were cut through seven times by streams representing a complete sequence from a small chine or glen, such as at St. Leonard's Gardens, to a main county artery such as the river that flowed through the park. Nowhere in a similar space could so many phases of river capture be studied. The amount of undulation of surface was very great, some of it was due to folds and anticlines, but it was largely due to denudation, and the way some of these deep valleys had cut back until there was only a knife edge between the next valley with hardly any ground at the back, proved a puzzle to every geologist. Stretching from Fairlight, near the coast, *viâ* Brightling, there was a high ridge known by those names, rising to 570 ft., from which most of the streams flowed. One, however, antedated the present surface features and cut down the ridge some 200 feet in crossing it; it now forms the beautiful valley in which the Alexandra Park is situated. The Director was inclined to hold that this valley antedated the anticline as we now know it, and that the Brede Valley had been brought about by earth movements associated with a "drift" with the palæolithic implements then before them. There could be no doubt that the Fairlight-Brightling ridge with its extension from the west, once extended obliquely over the Channel into France, and formed the watershed of the west and north rivers.

Near Fairlight a river passed over what is now the ridge in a southward direction. This old valley occurs now as a deep indentation in the cliff falling to about 250 ft. O.D., and, allowing 25 ft. fall per mile would have reached the level of the south river some ten or twelve miles south of the present coast line. A number of downthrows now occurred, the magnitude of which has apparently escaped attention. They threw down the high lands in the east, possibly sufficiently to be largely instrumental in the destruction of the old watershed and thus initiate the separation of England and France. From this newly-created lowland on the east a strike stream originated bisecting this old dip stream not far from the present coast, and this with the cutting back of the coast has left this relic of the old river valley, which to-day contains a sprinkling of a drift composed of highly coloured flints and almost as many quartzites, etc., as already described. A very large proportion of the flints were worked into various kinds of implements before the flint was altered to a warm orange brown. Upon the other side of the Brede Valley upon the next ridge to the north of Fairlight these dark brown implements also occur, as do the quartzites, which would point to this old river having crossed the present Brede also, and that the lower reaches of the Brede were also initiated by this and some other downthrows which had taken place here since the time the old Park river crossed the ridge. Many of the implements are of River-drift types; many are very bold work. The majority, however, are of French cave types. That these implements were not of Neolithic age and had acquired their stains where they were found was evident from the fact that many show signs of hard wear, and that there was upon the same spot in Neolithic times a settlement where implements of every known southern Neolithic type were found, barbed arrow-heads, adzes, axes, scrapers, knives, hammerstones, pot-boilers, missiles, cores, etc. These are not ironstained in the least, and are in the same state as they are in the other Neolithic stations close by. There was further another set which were made in Neolithic times out of the old brown Palæolithic implements and flakes, which leaves no possible doubt of the age of the old brown implements, even if their types did not help us.

The party then drove to Fairlight, stoppages *en route* being made to study the various points raised by the Director's address. A quarry in milk-white sandstone at the base of the Ashdown Series was visited near Fairlight Church, and a walk was then taken across the fields to the cliffs, passing into the old valley, where the sequence of events were again pointed out, and a half-hour's hunt over the fields rewarded the members with a goodly number of implements, flakes, etc., of all the various ages as well as specimens of quartzites and other erratics. The cliffs were next descended to the foreshore, where the magnificent display of the Fairlight Clays was much admired. After some amount of examination a discussion was initiated by the President upon the correlation of the coast beds with those inland, all agreeing that they were more nearly identical than is usually realised. Large cliff falls had recently cleared the cliff face so that the remarkable cross-bedding and overlapping was very pronounced. The members had the opportunity of witnessing a heavy and considerable fall of the cliff face.

The attractions of the structure of the rocks of the section impeded a very rapid progress, and in order to get back in time for the train the party had to ascend from the shore at Fairlight glen, the climbing up of which made them realise the amount of excavation that had been performed. A walk back *viâ* Barley Lane enabled the members to get a further grasp of the features. Tea was partaken of at the Queen's Road Restaurant. The President, proposing a vote of thanks to the Director in eulogistic terms, stated that he had again laid out a bigger programme than they were able to get through, so that there was yet more for them to come and see. A vote of thanks had already been proposed to Mrs. Lewis Abbott. The Director in reply thanked them for the vote of thanks, and also for the kind attention which they had given him all day. The members returned to London by the 7.15 train.

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EXCURSION TO GUILDFORD.

SATURDAY, JUNE 29TH, 1907.

Director: George W. Young, F.G.S.
Excursion Secretary: Miss E. Pearse.

(*Report by* The Director.)

Leaving Waterloo at 1.20 p.m., the party, twenty-five in number, on arrival at Guildford at once proceeded southward to St. Catherine's Hill, from which the physical geology of the district is well displayed. The "Hill" is an eastward-facing river-bluff formed by the cutting through by the river Wey of a well marked ridge of Folkestone Sands which runs parallel with the Hog's Back, and is continued on the other side of the river forming the Chantries and St. Martha's Hill. The two large chalk pits conspicuously seen on the opposite side of the river are Williamson's Quarry (left) and Rifle Range pit (right). The former was visited later in the day.

The Director pointed out that considerable earth movement had occurred here. A short distance to the south the Peasemarsh anticline had brought up the Weald Clay in the form of an inlier, and consequently the outcrops of the beds between the Weald Clay and the Tertiaries were narrow and the dip high. The dip, however, is not uniform, that of the Folkestone Sands, Selbornian, and Lower Chalk being much greater than that of the Middle and Upper Chalk. It was evident that either there was a sudden bending of the strata, or else an east and west strike-fault ran along the foot of the downs within the mass of the chalk. He favoured the latter suggestion for several reasons, one of which was the fact, which he would show presently, that the valley between the Chalk Downs and the Lower Greensand was not cut in the Gault as one would naturally expect, but was well within the Chalk itself. The theory that the Wey may possibly run in a syncline culminating in a dip fault was also alluded to.

The party then descended the face of the bluff, which affords a section of the Folkestone Sands. They are false bedded and ferruginous, and show many of the ramifying veins of iron so often found in these sands. A copious spring breaks out at the base of the north-east corner of the hill, and is said never to fail even in the driest summers.

The site of the "Pilgrims' Way" is believed to have run along the northern flank of the Lower Greensand, and that the Pilgrims crossed the river here by a ferry which still exists, and of which the members availed themselves.

Proceeding eastward along the "Pilgrims' Way," and skirting the north side of the Chantries, a pit in the Folkestone Sands was soon reached, and just beyond it the path to Warren Farm pit turns off to the north. The outcrop of the Gault is only a few yards wide, and then a very small overgrown pit shows Upper Greensand. Warren Farm pit is a long, narrow and rather deep quarry running along the strike. It is in Lower Chalk, and the beds dip at a high angle. The north face is cut in the zone of *Holaster sub-globosus*, which passes down into Chalk Marl (zone of *Ammonites varians*). Some of the typical fossils of the latter zone were soon found on the southern face and on the talus below it.

Looking northward from Warren Farm pit across the valley towards Echo pit, the striking fact before referred to that the floor of this valley is not cut in the Gault becomes obvious, and as the party made their way across it the entire absence of water was remarked as confirmative of its being cut in chalk.

Echo pit is in the lower part of the face of the escarpment. It has not been worked for many years, and has been largely planted with ornamental trees, through which the pathway winds leading to an open lawn-like expanse at the foot of the main face. It is altogether a beautiful and secluded spot, permission to visit which had been kindly granted by Col. H. H. Godwin-Austen, who wrote regretting his inability to attend through ill-health. The reason of its name very soon became evident, for the Director's remarks were accentuated by the remarkable echo in a most amusing manner. The base shows a few feet of flintless chalk of the *Terebratulina gracilis*-zone, succeeded by hard chalk containing many bands of nodular flints belonging to the zone of *Holaster planus*. The flint bands are at more regular intervals than usually happens in this zone, and at first sight might lead one to class it as the zone of *Micraster cor-anguinum*, but the fossils quickly dispel any such idea. A few minutes' search yielded *Holaster planus*, *Neithea quinquecostatus*, *Spondylus spinosus*, and the very large form of *Terebratula semiglobosa*. No true chalk-rock was observed, nor is it recorded here by the Survey. The upper part of the pit is inaccessible, but there the rows of flints are apparently less numerous. Attention was called to the gentle dip of the beds in this pit as compared with that in Warren Farm pit.

Chimney pit was next visited. It is but a short distance to the east of Echo pit, but is at a higher level. The base apparently corresponds to the upper part of the Echo pit, and probably belongs to the *Holaster planus* zone, but it is mostly obscured by talus. The greater part of the face is cut in the zone of *Micraster cor-testudinarium*. Fossils are fairly numerous, but owing to the hardness of the chalk are difficult to extract and clean without breakage. Near the middle of the section is a bed containing many Polyzoa. Flints are decidedly less numerous than in the Echo pit, and there are several rather thick beds of yellowish nodular chalk, whilst near the top is a pronounced orange-coloured nodular band, reminding one of the similar band in the same zone at Chapel Rock, near Lyme Regis. The orange band is evidently near the top of the zone, as the Micrasters found above it are indicative of the lower part of the zone of *M. cor-anguinum*.

So far as the writer is aware this is the only locality along the North Downs where the crest of the escarpment is formed by chalk of so high a zone, and yet its height here is only 375 ft. O.D.

The party then returned to Guildford for tea, after which it was decided to change the order of programme on account of the bad light and the threatening appearance of the weather, so a move was made to the old chalk pit in York Road, where the *Marsupites* zone is well exposed. The chalk is very soft, as is usual in this zone, but special attention was drawn to the large number of scattered nodular flints present, because generally this zone contains very few flints. They are mostly black and solid inside. *Marsupites* plates are abundant, and numerous specimens were quickly found, specimens of *Echinocorys scutatus* were also found, they being ot the tall sub-pyramidal variety characteristic of this zone. *Micraster* was not common, and *Echinoconus* decidedly rare. Mr. Wright found one specimen of *Actinocamax granulatus*. For permission to visit this and the next pit the members were indebted to the courtesy of Mr. David Williamson.

Proceeding by way of High Street, and passing through the grounds of Guildford Castle, the members finally visited the old quarry in Quarry Street. This is a huge excavation, now disused, and partly clothed with ivy, which, aided by the strikingly regular lines of flints dipping gently northwards at an angle of about 8°, gives a pleasing picturesqueness to its aspect. A platform at the northern end gives a splendid view of the whole gorge of the Wey, from the low ground of the London Clay on the north to the Weald Clay of Peasemarsh on the south, the latter being backed by the distant heights of the Lower Greensand of Hindhead and Blackdown. The section is very similar to that at Echo pit, except that it is nearly at right angles to the scarp, consequently the zone of *Terebratulina gracilis* is seen at the southern end only, the remainder being in that of *Holaster planus*. No definite evidence of the presence of the zone of *Micraster cor-testudinarium* has yet been obtained, but the northern end is much obscured by vegetation. It being now nearly dark, fossil collecting was out of the question, so the party made their way to the railway station, and returned to town by the 8.20 train. On arrival there it was found that a terrific thunderstorm had occurred, and much flooding of the low-lying districts had taken place. No rain, however, had fallen at Guildford.

The beds examined in the day's traverse are shown in the following table:

Upper Chalk	Zone of *Marsupites testudinarius*.
	„ *Micraster cor-anguinum*.
	„ *Micraster cor-testudinarium*.
	„ *Holaster planus*.
Middle Chalk	Zone of *Terebratulina gracilis*.
	„ *Rhynchonella cuvieri* (not seen).
Lower Chalk	Zone of *Holaster sub-globosus*.
	„ *Ammonites varians*.
Selbornian	Upper Greensand.
	Gault (not seen).
Lower Greensand	Folkestone Sands.

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EXCURSION TO ROCHESTER, WOULDHAM, AND BLUE BELL HILL.

JULY 9TH, 1907.

Director: G. E. DIBLEY, F.G.S.

Excursion Secretary: H. KIDNER.

(*Report by* THE DIRECTOR.)

FAVOURED with delightful weather the party arrived at Strood Station at 10.31 and were met by the Director, who pointed out the chief features of the large pits known as "The Quarry" immediately to the north, consisting of the base of the *Micraster cor-anguinum* beds, and capped with drift towards the east. Since the Association last visited these pits a large amount of the spur has been cut back towards Frindsbury Church.

Crossing the Medway, attention was drawn to the prominent features in the landscape, and several points of archæological interest were pointed out. Proceeding by the High Street past "The Bull Hotel," of Pickwickian fame, the Cathedral, and Watts' "Poor Traveller's House," the members reached the Rochester Museum, where they were met by the Curator, Mr. George Payne, F.S.A., who welcomed the Association. The Director led the way to the Geological Room and briefly explained the chief features of interest. This was greatly facilitated by the excellent illustration of a geological section of the district prepared by Mr. C. Bird, B.A., F.G.S.

After having inspected the Chalk fossils which, unfortunately, had not been localised, an omission in no way due to the present Curator, Mr. Payne gave a brief history of the fossils of the Pleistocene deposits of the district, the most recent being a magnificent tusk of *Elephas primigenius* exhumed, transferred, and mounted by the Curator. This tusk is 10 ft. 6 ins. in length, and was discovered in the Drift which caps the

Chalk near the river at Messrs. Peter's works, Wouldham. Undoubtedly it is one of the finest specimens known. A visit was then paid to the other parts of the building; the Roman pottery from Upchurch, the Prentis collection of Kentish birds, and the Saxon and other antiquities, and the Dickens collection are all of great interest.

In the unavoidable absence of the President, Mr. E. T. Newton, F.R.S., Vice-President, moved a hearty vote of thanks to Mr. Payne for his courtesy, and felt he was expressing the thoughts of the members when he said that the citizens of Rochester ought to be really proud in possessing such an interesting building—a Museum in itself—and to find so able and enthusiastic a gentleman as its Curator; he could testify to Mr. Payne's skill and ability from the manner in which he had procured intact and mounted so splendid a specimen as the tusk already referred to; not only in this department but in every branch the same loving care was exhibited, no matter whether in the objects or the building.

Mr. Payne, in responding, said he should at any time be pleased to welcome and assist any members of the Geologists' Association should they favour Rochester with a visit. A move was then made towards the Cathedral, of which a brief inspection was made.

Proceeding southwards by way of Boley Hill towards Borstal lovely views of the Medway were obtained, after passing St. Margaret's Church. At Fort Clarence the Director drew attention to the fine gorge immediately in front of them, and to the chief features of the pits as regards the zones of Chalk on the opposite side of the river. He hoped that they would be visited next year. Arriving at Borstal the party made their way to the Borstal Manor pit, which is situated in the *Micraster cor-testudinarium-* and *Holaster planus*-zones.

A goodly number of fossils were obtained, including some fine *Micrasters*, an unusually good example of *M. præcursor*, *M. leskei*, *Holaster planus*, *Cyphosoma radiatum*, *Lima hoperi*, *Ostrea lateralis*, etc.

The next pit visited was that of Messrs. Tingey & Co., at Wouldham, situated in the *Terebratulina-* and *Rhynchonella cuvieri*-zones. Unfortunately, nothing of importance was found on this occasion, though this pit has yielded exceedingly interesting specimens of *Conulus subrotundus* and teeth of *Ptychodus*. Quite recently the Director obtained from this pit an associated set, comprising 129 teeth of *P. polygyrus*, which are of great importance, as so large a number exhibit the graduations in size and ornament from the outermost to the central rows of teeth. By the aid of the few associated sets in which the teeth are *in situ*, and from a similar set of *P. rugosus* obtained from the Chalk of Kansas, and figured by Williston and Stewart, the

Director has been enabled to show both the upper and lower dentition of *Ptychodus*.

The next move was to the village of Wouldham, where refreshment was obtained, and then past the Free School pit to Messrs. Peters's large excavations. Here four members, who availed themselves of the mid-day arrangement, joined the party. The largest of these pits is worked in the bottom of the Lower Chalk. The second working comprises the top part of the *Holaster sub-globosus* Chalk, and part of the *Actinocamax plenus* marls. From this part a number of fossils were obtained, including *Ctenothrissa microcephala*, echinoderms, and wood. The third or highest workings are in the *A. plenus* marls and *Rhynchonella cuvieri*-zones. A beautiful specimen of *Hemiaster minimus* was obtained by one of the members. About 25 feet from the base of the highest pit flint-nodules occur, this being the lowest horizon at which they have been observed by the Director. Many fine examples of fish remains have been obtained from this working by the Director as well as from the middle quarry, which, within the past two years, has yielded the best known English example of an associated set of teeth of *P. decurrens* found *in sitû*; the earliest record in Europe of *Mosasaurus* in the form of vertebræ, and also the best English example of the lizard *Coniosaurus crassidens*. The foregoing may now be seen in the British Museum.[*]

Leaving this pit, the members proceeded to the celebrated Blue Bell Hill Pits. Upon arriving at the spot where a descent is made to the workings, the Director pointed out the features of this unrivalled exposure, the top of which is at a level of 770 ft. above O.D. It extends from the *H. planus* Chalk to the top of the Chalk Marl. In former days these workings yielded many fossils, but now owing to the upper pit being closed and to the employment of a steam navvy in the bottom working the possibilities of "finds" are very few. A descent was made into the workings and several fossils obtained, after which, in order to save time, the members were conducted through the chalk tunnel, which brought them to some large excavations in the Chalk Marl.

Owing to the flight of time it was deemed inadvisable to ascend Blue Bell Hill and visit Kit's Coty, though three or four of the members attained their object in this direction.

The party then proceeded to "The George" Hotel at Aylesford.

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[*] The uppermost pit of these workings has since the excursion been visited by the Director and Mr. Mark Wilks for the purpose of examining the base of the *Rhynchonella cuvieri*-zones. Several plateau-shaped masses of *Actinocamax plenus* marls capped with a layer of the *Rhynchonella cuvieri* have been left, and exposure to the action of the atmosphere has had the effect of revealing the contents. As at Blue Bell Hill large patches were crowded with *Inoceramus labiatus* (= *mytiloides*), but the most peculiar feature noticed was the appearance of the Chalk, when examined by a lens. Myriads of prisms of calcite due to the disintegration of the testa of *Inoceramus* were seen. This interesting feature has not, the Director thinks, been observed elsewhere.

After tea, Mr. E. T. Newton proposed the usual votes of thanks, which were duly acknowledged. A portion of the party afterwards followed the Director to a fine section in the Folkestone Sands which were capped by Drift from which good examples of mammalian remains are frequently exhumed.

The station was reached by way of the river, which constitutes one of the prettiest walks connected with Aylesford and this part of the Medway. Immediately outside the station many tons of Kentish Rag, quarried from the Hythe Beds near by, were to be seen. The stones were crowded with casts of *Trigonia*, *Nautilus*, etc.

With the exception of a slight shower the weather had remained all that could be desired, and after a most enjoyable day, in which the walking powers of the members were tested, the return journey was made at 7.51 p.m.

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EXCURSION TO THE LAINDON HILLS, ESSEX.

JULY 13TH, 1907.

Director : A. E. SALTER, D.SC., F.G.S.

Excursion Secretary : T. W. READER.

(*Report by* THE DIRECTOR.)

A PARTY of 35 left Fenchurch Street Station at 2.30 for Laindon Station and arrived about 3.30. Several members of the Essex Field Club were present by invitation. At the station the Director referred to the boring mentioned in the account of the last excursion in 1888 (*cf.* references), when 342 feet of London Clay were passed through before reaching the Lower London Tertiaries. The station is about 148 feet O.D. At Mr. C. T. Johnson's brickyard, about 300 feet O.D., some redistributed London Clay was seen, and a well pointed out which had been dug for 27 feet chiefly in London Clay. A good supply of water was obtained after passing a bed of septaria. The outcrop of the Bagshot Sands being quite close it is probable that the occurence of water in such a position is due to slipping, similar to that seen later on at One Tree Hill. The septaria, which had been preserved by Mr. Johnson, yielded a good deal of teredo-bored wood. A stream near by, issuing from a spring, had formed a small, well-marked valley. Other springs along the junction of the Bagshot Sands and London Clay were pointed out, and Dr. Thresh's report on the water supply of this district referred to.

The party now proceeded to a section showing about 15 feet of Bagshot Sands situated on the right of the road leading to Lee Chapel. The sands are capped by one or two feet of hill-wash.

The Director stated that the sands were micaceous and pointed to some clay bands on the west side such as are characteristic of Bagshot deposits, and are well seen at Hampstead. He invited the members to search for fossils as he understood none had yet been found. Messrs. J. Francis and H. A. Rigg were soon fortunate enough to find two casts of lamellibranch shells hardened by oxide of iron, and others of the party found more or less determinable fragments of casts of shells. A detailed and prolonged examination of this pit would no doubt lead to good results. This is the second occasion upon which members of the Association have detected fossils in the Bagshot Beds of Essex (*cf. Proc. Geol. Assoc.*, vol. xi, p. 13, and vol. xix, p. 319). The specimens were kindly handed to Mr. Cole, Hon. Sec. of the Essex Field Club, for its museum.

At the top of the hill (385 feet O.D.) near the "Crown" the fine view northward was much appreciated, the hills about Brentwood, Billericay, Beggar Hill, and Danbury pointed out, and the gravel formation in the higher parts referred to.

The party then proceeded to a small gravel section near the "Crown." The Director pointed out that the gravel was composed of Tertiary flint pebbles, sub-angular flints, and sub-angular and rounded pieces of Lower Greensand Chert. He regarded it as the deposit of an old stream having connection with the Wealden area, and that the hill on which they were standing owed its existence as such to the strata below having been preserved by the gravel while all around the strata not so covered has been denuded away.

Another sand-pit on the left of the road to Dry Street and Vange was then visited. The clayey bands at the top were well shown, but no fossils were found. The Director pointed out that the beds were lying flat, thus differing from those seen in the next pit.

After walking about a mile the road on the right to Stanford-le-Hope was taken, and a pit at One Tree Hill seen. It was pointed out that the strata was much disturbed owing to slipping. A fine example of a small fault was seen, and also the spot about 6 ft. below the surface from which the Director had obtained a large portion of a human skull and other bones.

Between 4 and 5 ft. of hill creep was above the bones, which were all in the Bagshot Sand, the skull being full of sand. Although no signs of disturbance could be seen, a burial had no doubt taken place at some period more or less remote. The bones have been handed over to the Essex Museum by the Director.

From the top of the pit a good view was obtained of the Thames to the south and of the Rayleigh Hills, visited last year, to the East.

Good views to the west were also seen later on in the day from the road leading to Horndon beyond the new church, and several roadside sections in gravel examined. It appeared that in the sections in the west of the hill the gravel did not contain much, if any, of the Lower Greensand fragments so plentiful in the section already visited.

After tea at the "Crown" the President (Mr. R. S. Herries) proposed a hearty vote of thanks to the Director, and was supported by the President of the Essex Field Club (Mr. Miller Christy). The Director in reply stated that there was still much to learn about the Essex gravels, and he hoped that energetic members of both societies would thoroughly investigate them.

The party returned to London by the 8.30 train.

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EXCURSION TO DORTON, BRILL, AND ARNGROVE.

SATURDAY, JULY 20TH, 1907.

Director: A. MORLEY DAVIES, D.Sc., F.G.S.

Excursion Secretary: A. H. WILLIAMS.

(*Report by* THE DIRECTOR.)

THE party left Marylebone at 12.15 and reached Wotton at 1.30. A walk of a mile brought them, now numbering sixteen, to Dorton, where the Director pointed out the position of Brill Hill and Rid's Hill, with the Brickfield at its foot (Fig. 20). According to the Geological Survey Map they were then standing in the middle of the outcrop of "Lower Calcareous Grit," here

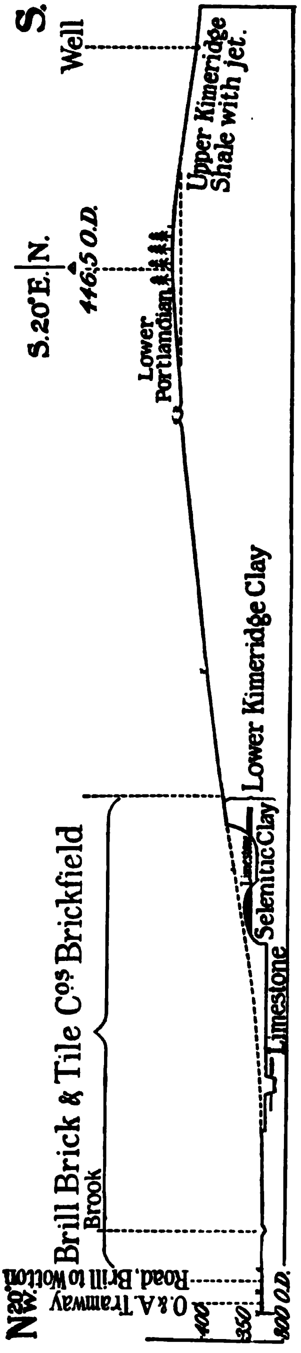

FIG. 20.—SECTION THROUGH RID'S HILL, BRILL—*A. Morley Davies.* (Length about 500 yards, scale vertical and horizontal slightly less than $\frac{1}{2500}$).

(Reprinted by permission from Quart. Journ. Geol. Soc., vol. lxiii (1907), p. 30)

represented by an *Exogyra nana* clay. The Director considered that the tracing of this outcrop by Mr. Polwhele, fifty years ago, through a clay country with no exposures except pond-diggings was an excellent piece of work. At the same time it was only natural that the Survey should have failed to discover the existence of a series of folds which brought up inliers of Oxford Clay in the midst of the Corallian outcrops. Of one such inlier evidence was seen at once in the cutting under the Dorton road bridge, which showed a dark clay with numerous large specimens of *Gryphæa dilatata*.

The Dorton cutting, which is on the new line of the G.W.R. to Birmingham, will eventually be forty feet deep, but at present only the upper half of this has been excavated, and a walk of half-a-mile along ground not yet opened up was necessary before a good section of Ampthill Clay was reached. This was a clay varying in colour from light grey to yellowish-white, with two bands of impure limestone. In some of the clay-bands, *Exogyra nana* was found to be extremely abundant, but a hunt for other fossils only yielded one small ammonite, apparently a *Perisphinctes*, one worn *Cidaris* spine (*C. smithii?*) an *Alectryonia gregaria* and a few doubtful forms.

Attention was called by Mr. Sikes, the resident engineer, to lumps of highly fossiliferous Oxford Clay, brought from the tunnel a little farther north, but the fossils were too fragile for much collecting to be done. They included *Cardioceras*, a clavellate *Trigonia*, *Modiola*, *Pecten*, and *Gryphæa dilatata*. The tunnel itself was not accessible, but the party made its way across the Brill tramway and through Rushbeds Wood to the cutting beyond the tunnel. Here the Director called attention to the curious gravelly drift, made up largely of fragments of iron-sandstone of all sizes, and lying in pockets in the clay, even penetrating under it in places. The clay itself had all the characters of Oxford Clay at the bottom of the cutting (black clay with *Cardioceras cordatum*), but higher up a band of oysters yielded both *Gryphæa dilatata* and *Ostrea discoidea*, the latter usually considered to be confined to the Ampthill Clay. No *Exogyra nana*-zone was seen, however, so the cutting had to be left with uncertainty as to whether it contained any Ampthill Clay or not.*

Returning to the road a short walk brought the party to the Brill brickfields, where a fine section of Lower Kimeridge Clay was seen. The clay at the base contained abundant selenite crystals, and some fine belemnites converted into selenite were found. Blocks of stone full of *Serpula tetragona* and *Cyprina cyreniformis* were broken up for specimens. From limestone bands at a higher level *Pholadomya æqualis* and *Pleuromya recurva* (with perhaps another species) were obtained; and still higher the zone of *Exogyra virgula* was found. Examination of the workmen's hoard enabled the Director and Mr. Newton to add to the recorded list of fossils the very characteristic species *Rhynchonella inconstans*, as well as vertebræ and other bones of *Ichthyosaurus* and *Plesiosaurus*.

Tea was taken at the Rose and Crown, Brill, after which the President proposed a sincere vote of thanks to the Director. The July train alterations had given the Director an extra three quarters of an hour to dispose of, and as a strong desire had been expressed to see the Arngrove Stone *in sitû* it was decided to do that in place of examining the sections on Brill Common. A waggonette was hired and the party divided into a driving and a walking section, and succeeded in reaching the Arngrove pits in time for a hasty examination of the stone and a quick return. Although the exposure seen was small, and the time short, every one was able to obtain good examples of this interesting stone, which is also known as "*Rhaxella* Chert," being very largely made up of the minute rounded spicules of that sponge (see p. 127). Several fossils were also found, such as *Cardioceras cordatum*, *Trigonia*, *Modiola*, *Serpula*, etc.

A return was made to London by the 8.10 train from Brill.

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* Further examination has shown the existence of *E. nana*-beds at the southern end of the cutting, and has revealed unexpected complexities of structure.—A.M.D., October 12th, 1907.

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EXCURSION TO IPSWICH AND CLAYDON.

IN CONNECTION WITH THE IPSWICH FIELD CLUB.

SATURDAY, JULY 27TH, 1907.

Directors: G. SLATER and Miss NINA LAYARD, F.L.S.

Excursion Secretary: A. C. YOUNG.

(*Report by* GEORGE SLATER.)

THE members started from Liverpool Street (G.E.R.) by the 12.45 p.m. train, reaching Ipswich Station 2.30 p.m., where about fifty members of the Ipswich Field Club were waiting to receive them.

The party immediately proceeded to the low hill west of Handford Bridge, and three-quarters of a mile north-west of the station. The hill is intersected by the railway between the London Road and the Hadleigh Road over-line bridges, and is bounded by the Hadleigh and London Roads, thus forming a triangle.

In the year 1900 the railway cutting was widened on the north-eastern side of the line for a distance of about 9 chains from the London Road bridge, the depth varying from 25 ft. to 30 ft., and in November, 1905, excavations were commenced on the Hadleigh Road by the local unemployed under the auspices of the Ipswich Town Council. A considerable number of men were engaged from time to time in cutting back the slope towards the line, preparing building sites, the extracted earth being transferred to the depression on the opposite side of the road.

A halt was made on the brow of the hill, where the geological structure of the district was briefly described. The Chalk is exposed in the valley of the Gipping for a short distance only, owing to the thick mantle of drift. It is seen in a small pit three-quarters of a mile south-east of Bramford Church, or one mile north-west of the Hadleigh Road excavations.* From this point towards the sea the top of the chalk gradually sinks below the surface of the ground.

The general succession of the beds above the Chalk in the immediate neighbourhood is as follows, the thickness of the beds being only approximate :

Boulder Clay	over 20 ft.
Middle Glacial	over 20 ft.
Crag	10 to 15 ft.
London Clay	27 ft.
Woolwich and Reading Sands	20 ft.
Thanet Beds	5 ft.
Chalk.	

It was pointed out that the scene of the excavations was evidently the outcrop of the London Clay and Crag with a little of the Woolwich and Reading sands below and Middle Glacial above, and the chief interest of the sections lies in showing the effect of the intense pressure of ice on yielding and plastic beds.

After referring to the general characteristics of the Boulder Clay of the Eastern Counties and the general behaviour of ice when passing over a country† (see the three papers by Mr. Harmer given in the references at the end of this report), the passage of ice down the Gipping Valley was briefly alluded to.

That the valley was the natural watercourse in glacial times was proved by the presence of certain gravels beneath the Boulder Clay which are composed of chalky gravel with boulders and derived fossils, and other *débris* of glacial origin. Specimens of washed Boulder Clays were exhibited. These gravels are well seen amongst other places at Haughley Ballast pit (Plate V, Figs. 14, 15), which was opened (1904) in order to obtain material for the Mid-Suffolk Light Railway, and in a new pit about half-a-mile south-east of Needham Market close to the highway opened in 1905. In the latter pit large blocks of Jurassic sandstone, septaria, and limestones have been obtained, and the following derived fossils, kindly identified by Dr. Kitchin of the Jermyn Street Museum (July 4th, 1906) :

Ostrea, probably derived from Ampthill Clay horizon,
Gryphæa arcuata, Lias,
Gryphæa (many specimens), very common,
Cardinia crassissima, Lias,
Ammonites jason.

A cup-shaped fragment of spheroidally weathered dolerite was also found.

The distribution of this gravel appears to be very irregular, and opens out many interesting problems.

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* See "Geology of the Country around Ipswich, Hadleigh, and Felixstowe," *Memoir of the Geol. Survey*, p. 7.

† H. B. Woodward, "The Chalky Boulder Clay and the Glacial Phenomena of the Western-Midland Counties of England," *Brit. Ass. Report*, 1897.

The question of the disturbance of the underlying beds by the pressure of great masses of ice was now dealt with. The amount of disturbance would naturally vary with the intensity of the pressure and the composition and relative resisting powers of the beds below the ice.

The ice-pressure would seem to have been greatest at the bottom of the valley, but would also appear to have varied according to the winding of the valley, having been greatest on the concave and least on the convex sides of the valley, in this respect seeming to have behaved very much like a stream of water.

This would account for the considerable amount of disturbance seen at Claydon, although the top of the pit reaches the 100 ft. contour (see also Plate V, Figs. 8 and 9), and for the great confusion so well seen in the Hadleigh Road excavation.

Where the pressure was very great "planing" action took place; in favourable regions the ice buttressing against and pushing along for considerable distances beds which impeded its progress. In these cases the Boulder Clay would rest horizontally on the underlying beds (see Claydon, Plate V, Fig. 7, north end of the pit, also the pit already referred to three-quarters of a mile south-east of Bramford Church).

Another interesting point proved by the Hadleigh Road and Railway sections was that pressure had not only been longitudinal —*i.e*, down the valley—but also lateral, the beds being distinctly disturbed both N.W. to S.E. and E. to W., that is, at right angles to the sides of the valley, a point extremely well shown in the whole of the Hadleigh Road excavations. The effect of ice pressure on the various beds shows some interesting results. Plastic beds like London Clay are contorted and bent into anticlines, the upper parts of which are often truncated, the masses removed being transported to some distance and becoming intercalated with other beds. The general action of the ice was then dealt with, and the remarks were illustrated by reference to Plate V, Figs. 1, 2, 3, 7, where buttressing action is well shown.

In the case of soft sands the general arrangement seems to have been the passing of the ice by gentle curves (Plate V, Figs. 13 and 8), with not much disturbance of the underlying beds.

The party now descended to the railway cutting, and by means of scale drawings were enabled to understand the main features of the section.

The Director pointed out that none of the material of the beds in the section was *in sitû*. Proofs that the masses of London Clay were disturbed were shown, curved bands of cement-stone being well seen. An interesting point in the cutting is the presence of oval-shaped transported masses of the Crag, which have evidently acted like "boulders." (See also Plate V, Fig. 12.)

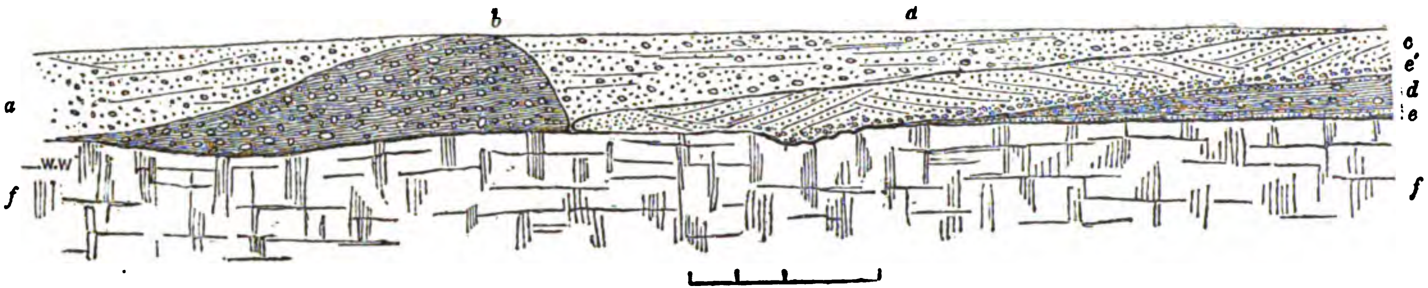

FIG. 21.—SECTION OF PART OF CLAYDON CHALK PIT, 1875.—*W. Whitaker.*

(Reproduced from Geol. Survey Memoir on Stowmarket by kind permission of His Majesty's Stationery Office.)

Scale, vertical and horizontal = 30 *feet to an inch.*

a. Sand and gravel, somewhat bedded, with a thin layer of grey clay near the top.

b. Pale Boulder Clay (may be the same bed as *d*.).

c. False-bedded coarse ferruginous sand, partly hardened into iron-sand-stone : a gravelly layer at the bottom, from bits of which lying about in the pit Mr. Whitaker got some phosphatic nodules : a hollow of flints at one spot, over the Chalk. Much like the Crag sand from which the shells have been dissolved out.

d. Grey Boulder Clay ; with a layer of the grey clay and a little of the greensand of the "base-bed" (Thanet) *along the top*, *e′* (*d* may be the same bed as *b*.).

e. Clayey greensand (base-bed of Thanet Beds), with green-coated flints, up to 1½ feet thick.

f. Bedded Chalk, almost flintless, 50 feet or more, and worked 10 feet deeper in another part. Small species of *Ostrea*, as at Needham Market.

It seems clear from the section that after the London Clay masses became "fixed" by slow and intense pressure, as shown by the unbroken curved lines of cement stone, the Crag masses were moved independently, streaks and trails of Crag in hollows of the London Clay being fairly common. (See also Plate V, Fig. 6, with Boulder Clay between Crag beds.)

Two sets of Boulder Clays are well marked in the Gipping neighbourhood, the buff or lower clay being characteristic of the valley. The Kimeridgian above is separated from this by a Boulder Clay wash in the Railway Cutting. But the two Boulder Clays are seen at the Explosive Works, Stowmarket, without any gravel between, the two being only distinguished by colour. In many sections the two merge imperceptibly into one another.

The party now proceeded to examine the Hadleigh Road cuttings. At the present time the excavations are in what is practically a much disturbed outcrop of Crag sand, and though some fine sections are still to be seen showing disturbed beds at high angles (Plate V, Figs. 4 and 5), yet many of the best sections are now removed.

Diagrammatic sections showing the general arrangement and disturbance of the beds were shown (Plate V, Figs. 2 and 3), with the general explanation of the cutting as revealed from time to time.

A fine series of photographs of the excavations taken by Mr. P. Boswell, F.G.S., was shown exhibiting many peculiar and interesting features in sections now removed, with scale drawings showing the shearing and contorting of beds of sand gravel and masses of Crag.

Perhaps the finest features of these excavations, now unfortunately utterly removed, were the fine anticlines of London Clay with bands of Cement Stone. It is a remarkable fact that the Cement Stone bands formed in many places unbroken curves pointing unmistakably to the enormous pressure and extreme slowness of the ice action. It is also significant that on the opposite side of the valley, not more than a mile distant, no trace of disturbance in the London Clay has been seen, although two pits in the London Clay, on the same level as the Hadleigh Road Cutting, have been worked for many years. The sharp bend in the valley so well shown on the contoured ordnance map, has resulted in the site of the Hadleigh Road excavations, which is on the concave side of the valley, being exposed to the full force of ice pressure coming down the valley, whilst the narrowing of the valley at Ipswich would naturally increase the lateral pressure.

Miss Nina Layard, F.L.S., gave a short account of an Anglo-Saxon cemetery on the spot which was opened during the early portion of last year. She personally examined 159 graves. The cemetery was of irregular shape, about 400 ft. by 105 ft., and is believed to have been a pagan burial place of the sixth century.

The bodies were all buried in a horizontal position with arms at the sides. Numerous relics came to light in the shape of weapons, articles of personal adornment, household utensils, pottery, glass, and beads; these were found buried with the skeletons. There were also about two dozen urns for holding cremated remains. The pottery was in all cases very rough, and in the few instances in which it was adorned the decoration consisted of indentations made by pressure of the thumb from within the unbaked pot, while a peculiar feature of the cemetery was that though numbers of spear-heads and javelins were discovered not a single sword was found.

The relics include:

42 spear-heads, 77 knives, 16 bosses of shields, 32 necklaces of beads containing 848 beads, one necklace composed of a silver ring, 16 small bronze buckles, 4 glass drinking cups, and many other remains which throw much light not only on the burial customs but on the actual living customs of our Anglo-Saxon ancestors.

A hearty vote of thanks to Miss Layard was proposed by Mr. Slater and seconded by Mr. Herries on behalf of the Geologists' Association.

Leaving the Hadleigh Road excavations the members left Ipswich Station at 4.35 p.m. for Claydon, where tea was provided by the Ladies' Committee of the club in the beautiful grounds of the rectory at the invitation of the Rector (The Rev. Ansell Jones) and Mrs. Jones, to whom, as well as to the ladies, Mr. Slater proposed a vote of thanks. In seconding it Mr. Herries took the opportunity of asking for a hearty vote of thanks to Mr. Slater for the interesting excursion which he had provided. All these votes were carried by acclamation.

After tea the Claydon Chalk Pit was visited, and the fine exposure was explained in detail (Plate V, fig. 7). The whole section has been cleared and measured by the Director, and by means of drawings supplied the various features were easily followed.

The section Fig. 21* corresponds with the southern half of the present section, although the pit has been cut back a considerable distance since 1875. The buttressing of Boulder Clay is extremely well marked at the northern end. The hard beds are decalcified Crag, shells and a bone having been found by the Director. The two masses of Boulder Clay were also proved to be connected, and to form part of the same bed. The Boulder Clay is the buff or valley variety, not the plateau or Kimeridgian type.

The remarkable planing action of the ice on clay of the

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* "Geology of the Neighbourhood of Stowmarket," W. Whitaker and others, 1881, p. 10.

Thanet series was dwelt upon (Plate V, Fig. 7, dark bands), and the large Chalk Boulder (42 ft. long) was clearly seen.

The section generally represents buttressing and over-riding by the ice of masses of Crag and sands; the thrusting of the wedge of Boulder Clay beneath Thanet beds and Crag being probably due to the beds being frozen in the ice and carried to higher levels by means of thrust planes in the ice.

The pot-holes, a common feature of the Chalk in the neighbourhood, were also explained. The large one at the South end, now obscure, was revealed January 1st, 1905. Its depth was as much as 57 feet. After a hard frost followed by a thaw the face of the cliff fell out, and a large quantity of sand filled with *débris* a pit below 15 ft. deep, doing considerable damage.

After referring to Trimmer's researches (see References), it was pointed out that there was no clear evidence as to the age of the pot-holes in the present pit, the probability being, however, that they were pre-Eocene. Photographs were exhibited of the pot-hole during various stages.

Proceeding to the little village of Whitton, the party caught the electric car to Ipswich Station, leaving for London about 8 o'clock.

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LONG EXCURSION TO THE APPLEBY DISTRICT, WESTMORELAND.

AUGUST 15TH TO 24TH, 1907.

Director: JOHN EDWARD MARR, SC.D., F.R.S.
Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR.)

A PARTY numbering about 45 assembled at the Tufton Arms Hotel, Appleby, on the evening of Wednesday, August 14th, to study the geology of the surrounding district, and remained until Saturday, August 24th. They were fortunate in being favoured with good weather during the greater part of their stay, the only rain of any importance falling on the 22nd, when they visited Shap Quarries, and on that day the drive to and from Shap was accomplished without rain. The broken weather was in reality beneficial, allowing of excellent views owing to the clearness of the hills.

THURSDAY, AUGUST 15TH.

The members of the Association first ascended the river banks above the town, where the Director explained the general geology and its influence upon the main scenic features. Beneath them was the Eden in an incised meandering valley, now being modified by the formation of alluvial flats and the partial extinction of the old spurs. The advantageous position of Appleby, built on one of these spurs, with its castle commanding the higher part of the spur, was seen. The comparatively low ground of Edenside, occupied by the New Red Sandstone rocks, was pointed out as extending to about two miles west of Appleby and three to four miles east of that town. Looking east over Edenside, the party saw the great scarp of the Pennine Chain, composed of Carboniferous rocks, with the pointed hills of Lower Palæozoic rocks fronting the scarp. It was explained that a small fault—the Inner Pennine Fault—lay between the pointed hills and the scarp behind them, while a great fault—the Outer Pennine Fault—lay immediately in front of the Lower Palæozoic hills, separating them from the lower ground occupied by New Red Sandstone. It was stated that a third fault—the Middle Pennine Fault—also existed, separating older Ordovician strata on the east from higher Ordovician and Silurian beds in the west. Turning westwards, the Director explained that the Lower Palæozoic tract of Lakeland seen in the distance was succeeded by terraced ground composed of Lower Carboniferous strata, and that these strata were unconformably overlain by the New Red

Sandstone rocks, though no section showing the unconformity could be seen.

The party then walked across the New Red Sandstone strata to Hilton village. The position of the Lower Brockram was pointed out and the false-bedded Penrith Sandstone examined in the street of Bongate, after which the party proceeded to Hilton Beck. Here the Director indicated the position of the Upper Brockram in the middle of the Penrith Sandstone. The Hilton Shales were examined, and a few plants were found therein. On approaching Hilton village a good section of the St. Bees Sandstone was observed in two quarries, and in the more easterly section a tongue of drift was seen forced beneath a projecting mass of the Sandstone (see Plate VI, fig. 1). On reaching the village the party lunched, and then walked up the Beck to the Scordale Lead Mines. The position of the Outer Pennine Fault was shown near the old Smelt Mill, beds of Caradoc age (Dufton Shales), being seen within a few yards of the St. Bees Sandstone. Farther up stream the general position of the Middle Fault was indicated, and shortly after this an exposure of Skiddaw Slate was examined.

The Inner Fault was in turn crossed, and the party found themselves on Carboniferous rocks. These were examined near the Lead Mines, where the Whin Sill was also hammered, and Mr. Fearnsides noticed that the heavy-spar which was being worked occurred in lenticles beneath the Whin Sill.

From Hilton village the party drove back to Appleby, which was reached at a quarter past six. After dinner, the Director having been misinformed, and believing that it was customary to explain the day's proceedings by aid of a blackboard, proceeded to do so, and was induced to do the same on succeeding evenings.

Friday, August 16th.

The party drove to Knock, starting at 9.30, and devoted the day to a detailed study of the succession and characters of the Lower Palæozoic strata. Leaving the village, and ascending Swindale Beck, the general position of the Outer Pennine Fault was indicated. The first rocks to be hammered were of Wenlock age (Brathay Flags), and yielded a good specimen of *Monograptus priodon*. It was explained that as the beck was ascended lower strata were met with. The next beds examined were the Browgill deposits (of Gala-Tarannon age). Here a considerable number of graptolites of the higher zone (including *Monograptus crispus*, *M. marri*, and *Retiolites geinitzianus*) were obtained, and specimens of the mica-trap dyke which breaks through the Browgill beds at the junction of Swindale and Great Rundale Becks were secured. This is the dyke which is figured in Dr. Teall's "British Petrography." The party secured several corroded phenocrysts of felspar like those of the Shap Granite from this dyke, also samples of other inclusions, one of which resembled the quartz-porphyry of Dufton. The position of the *M. turriculatus*-zone was shown; it was explained that the Skelgill beds were here faulted out, though exposed in Great Rundale Beck, where they were subsequently seen by some of the party. The highest Ordovician rocks, Ashgill Shales, were indicated, and then attention was called to a grey nodular limestone, which the Director claimed to be "Keisley Limestone." Hammers were soon at work, and some fossils extracted. One found by Mr. H. Bassett, apparently a *Staurocephalus*, was kindly handed by him to the Director, and the President made a remark, which should be recorded, to the effect that specimens which were of use to the Directors of excursions should in most cases be given to them. The present Director gratefully acknowledges that this was done whenever a specimen of interest to him was found.

The party had hitherto been floundering along a steep bank through under-

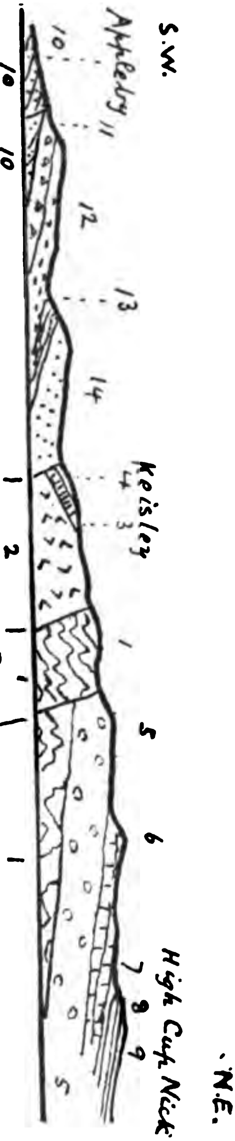

FIG. 22.—SECTION FROM APPLEBY TO THE SUMMIT RIDGE OF THE PENNINES.—*J. E. Marr.*

14. St. Bees Sandstone.
13. Hilton Shales and Red Marls.
12. Penrith Sandstone and Upper Brockram.
11. Lower Brockram.
10. Millstone Grit.
9. Tyne Bottom Limestone.
8. Whin Sill.
7. Shales, Limestones and Grits.
6. Melmerby Scar Limestone.
5. Basement Conglomerate.
4. Stockdale Shales.
3. Keisley Limestone.
2. Rhyolite.
1. Skiddaw Slates.
I.P.F., Inner Pennine Fault.
M.P.F., Middle Pennine Fault.
O.P.F., Outer Pennine Fault.

Scale: 1 in. = 1 mile.

growth, but now reached open moorland, where they lunched and examined the Dufton Shales, from which some fossils were extracted. After this the Corona Beds were tapped, and it was pointed out that some of the limestone bands therein were largely composed of ostracods. These Corona Beds repose on the rhyolitic group of rocks which form Knock Pike, and specimens of the interesting eutaxitic rhyolite with inclusions of an earlier andesite were obtained from the beck. Higher up stream the Middle Pennine Fault was actually seen with rhyolite to the west, Skiddaw Shales to the east, and a crush-belt along the fault with an intrusion of mica-trap. From here some of the party ascended Knock Pike, while others visited the Skelgill Beds of Great Rundale Beck and the quartz-porphyry with large phenocrysts of biotite, which is exposed on the western flanks of Dufton Pike. Tea was obtained at the Pack Horse Inn, at Knock, and the party drove back to Appleby, which was reached at 6.45.

SATURDAY, AUGUST 17TH.

The party drove to Hilton at 9.30, the object of the day being study of the geology of Roman Fell. The Ordovician rocks of the western slopes were examined, and some fossils, including *Lingula tenuigranulata*, extracted from the Corona-beds. Ascending one of the streams which seam the western face, the party soon reached the "Polygenetic" conglomerate, a boulder conglomerate containing a great variety of pebbles in a somewhat incoherent matrix. Many of the pebbles are slickensided, bent, and even faulted. Higher up the Fell another conglomerate, the Roman Fell Conglomerate, was reached. This consists chiefly of hard, yellow-brown sandstone with many seams of quartz-pebbles. The unconformity between these conglomerates and the Lower Palæozoic Rocks was clearly discerned.

Thence a move was made to the summit of Roman Fell, where it was seen that the sandstone is often superficially converted into quartzite by recent weathering. Proceeding southwards, a cross-fault, which brings the Melmerby Scar Limestone against this conglomerate, was reached, and from this point a fine view was obtained of the broken blocks of ground occupied by the Lower Carboniferous rocks near Brough. It was seen that the downthrow of the faults was constantly to the south, and the Director showed how this was connected with the dying out near Brough of the Outer Pennine Fault. The line of fault separating the conglomerate from the Melmerby Scar Limestone was followed down the east side of Roman Fell to Swindale Beck (a different beck from that visited on Friday). In this beck a limestone was pointed out from which Prof. Garwood has obtained fossils which prove that it is below the *Dibunophyllum*-zone. Mr. Whitaker, struck with some swallow-holes during the descent took some of the members to the summit of the Melmerby Scar Limestone on the east side of Swindale. There they were rewarded with a view of a fine series of these holes. The party had tea at Hilton and drove back to Appleby, which they reached about 6 p.m. After the blackboard demonstration in the evening Mr. Whitaker kindly gave an explanation of the nature and mode of formation of the swallow-holes.

MONDAY, AUGUST 19TH.

The members of the Association at 9.30 drove to Harbour Flat under the Fells, and walked up the bottom of the High Cup Valley to High Cup Nick (see Plate VII, Figs. 1 and 2). The hills were singularly clear and fine views were enjoyed. The cirque-like character of the head of the valley with its precipice carved in the Whin Sill topped by the Tyne-Bottom Limestone was noted, and attention called to the cutting back of the High Cup Valley into the Maize Beck, drainage-benches of the old valley, which was tributary to Maize Beck, still existing on either side of the upper part of the High Cup Valley. Many of the party, in order to get a better view, ascended Narrowgate Beacon and walked along the ridge. Ingleborough to the south, the Lake District Hills to the west, and Criffel on the other side of Solway were all clear, and the party therefore had an exceptional opportunity of seeing the courses taken by the glacial boulders which eventually found their way over Stainmoor. The members had tea at the Stag Inn at Dufton, and after examining the quarries in the St. Bees Sandstone returned to headquarters.

TUESDAY, AUGUST 20TH.

An alteration in the order of the programme was made, and this day devoted to Melmerby. The party drove along the Fells, seeing the structure of the Pennine Chain along the whole of that portion which is flanked by Lower Palæozoic rocks. A slight detour was made to see the village of Milburn, for many years the abode of the late Mr. J. G. Goodchild, whose papers on the geology of the district, especially with reference to the glacial phenomena, are so well-known. Reaching Melmerby the party examined the unconformity between the Skiddaw Slates and the polygenetic conglomerate on the fell-road south of Rake Brow. The great fault which brings the Melmerby Scar Limestone from Melmerby High Scar to Melmerby Low Scar was shown, and it was observed that its throw was in the opposite direction to that of the faults about Brough, it being connected with the northerly diminution of the throw of the Outer Pennine Fault. Walking along Rake Brow the lavas and ashes of the Eycott Series of the Borrowdale volcanic group were hammered, including a handsome rock with large plagioclase phenocrysts.

Farther on the Middle Pennine Fault was crossed, and the rhyolitic group seen, with a Tertiary dyke breaking through its rocks. On reaching the Alston Moor Road these rhyolitic rocks were seen to be succeeded by the Corona Beds, from which fossils were extracted. Tea was obtained at Melmerby, and the party thence drove back to Appleby.

WEDNESDAY, AUGUST 21ST.

This was essentially a day for collecting. Driving to Dufton an ascent of Pusgill Beck was first made. The Dufton Shales of that beck were hammered, and higher up stream the Corona Beds were found. This is the best section for obtaining *Trematis corona*, and a fine suite of that fossil and other organisms was obtained.

A good view was seen to the north, showing the position of the three great faults (see Plate VI, Fig. 2, which shows the notches). The Inner Pennine Fault was seen to be responsible for the notch between Brownber and the main scarp, the Middle Fault for the notch between Brownber and Dufton Pike, while the Outer Pennine Fault was marked by the appearance of the low ground occupied by New Red Sandstone to the west of Dufton Pike.

Here the party divided, some ascending Dufton Pike, others visiting Brownber to see the Skiddaw Slates converted into sericite schists along the folded quartz-veins as the result of pressure-metamorphism. Those who had not seen the Dufton quartz-porphyry now visited it and obtained specimens, and the party reunited for tea at the Stag Inn, Dufton. Afterwards they visited Keisley, where the Director explained his views as to the limestone (see *Geol. Mag.*, Dec. v, vol. iii, p. 481). Before inspecting the limestone the Director pointed out the shales of the *Dimorphograptus*-zone of the Skelgill-beds, faulted against the limestone, and from these shales Mr. L. E. Ridley found (and handed to the Director) a very beautiful specimen of *Dimorphograptus*. From Keisley a return was made to Appleby, some of the party driving, others walking through Flake Bridge Wood.

THURSDAY, AUGUST 22ND.

The party drove to the Shap Granite Works, *viâ* Morland. The first halt was made at the road-metal quarries in the Andesitic series by the high road on the north-east side of the granite. Here excellent specimens of the metamorphosed rocks were obtained, more especially of the altered metalliferous veins which seam the andesitic rocks. Specimens of garnet, actinolite, epidote, and pyrites were extracted from these veins, one specially fine specimen found by Mr. W. H. Barnes being handed to the Director. The party walked along the tramway to the quarry, seeing on the way a junction between the granite and the rhyolitic series, and further on, *moutonnée* surfaces of granite showing well-marked striæ. On reaching the quarry, the granite and its "inclusions" were examined. It was pointed out that many of the "inclusions" were more basic than the granite itself, and contained corroded phenocrysts of the felspar typical of the granite, with plagioclase borders. The resemblances between these "inclusions" and the mica-trap dykes were noted, and the Director explained that the relationship between these was the reason of their visit to Shap, which was necessary in order that they might understand the significance of the mica-traps of the Appleby tract. From here a move was made to Wasdale Head Farm, and a study of metamorphism of the Upper and Lower Coniston Limestones, and of the intercalated rhyolitic flow made. The party returned to Shap, where they had tea, and drove back to Appleby.

FRIDAY, AUG. 23RD.

The members took train for Ravenstonedale, where they arrived at 12.14. From the station the Director described the general features, pointing out that they were in a horseshoe-shaped valley which lay in a geological trough between the dying-out Lake District anticline on the north and the Howgill Fell anticline on the south. He explained how the Lune rose on the former anticline at Shap Summit, and cut through the greater Howgill anticline to the south, forming the gorge between Tebay and Low Gill, and that the river rising near the station flowed into the Lune.

Walking by Friar Bottom to Colbeck, the case of capture of the headwaters of this portion of the Lune drainage by the tributary of the Eden which has cut the gorge near Smardale station was explained. An account of this will be found in the paper on the "Geology of the Appleby District," written by the Director (*ante*, *p.* 146). From Coldbeck the party went through the village of Ravenstonedale to Stane Gill, where they saw the Z. beds of the Lower Carboniferous rocks and extracted fossils therefrom, the finest specimen being presented to the Director by Mr. H. Vassall. Returning to the village, they had tea at the Black Swan, then made their way to Kirkby Stephen by road or rail, and visited the remarkable pot-holes worked by the river Eden in the well-jointed Brockrams of Stenkrith Bridge. The party returned to Appleby at 7.3.

After dinner the President (Mr. R. S. Herries) proposed a vote of thanks to the Director, Mr. E. P. Ridley one to the Excursion Secretary (Mr. A. C. Young), and Mr. Potter one to the President. The recipients of the votes replied. It was agreed, on the suggestion of Mrs. Ridley, that a letter, signed by all present, should be sent to Mr. Griffith, who had been present throughout the excursion until that morning, congratulating him on the attainment of his eightieth birthday. This was done, and thus ended the Long Excursion of 1907.

Before leaving Appleby most of the party visited the quarry in the Lower Brockram at Burrells, south-west of Appleby. An animated discussion as to its origin took place, Mr. R. D. Oldham and Mr. Brook-Fox taking an active part.

The references have already been given on pages 147 and 148.

EXCURSION TO READING (BERKSHIRE).

SATURDAY, SEPTEMBER 28TH, 1907.

CENTENARY CELEBRATION OF THE GEOLOGICAL SOCIETY OF LONDON.

Directors: MR. H. W. MONCKTON, Treasurer of the Geological Society, MR. O. A. SHRUBSOLE, F.G.S., and MR. H. J. OSBORNE WHITE, F.G.S.

Excursion Secretary of the Association: MR. A. C. YOUNG, 17, Vicar's Hill, Lewisham, S.E.

(*Report by* THE DIRECTORS.)

THIS excursion was held in connection with the celebration of the Centenary of the Geological Society, and the Fellows of the Society and their Foreign, Colonial, and British guests were invited to attend. The President of the Association, Mr. R. S. Herries, with a party of about fifty, left Paddington Station at 9.50 a.m., and reached Reading at 10.38.

From the station the members walked to the Reading Museum. The first room contains the fine collection of coins, metal implements, glass, pottery, etc., from the Roman town of Silchester, which is situated less than 13 kilometres a little west of south of Reading. After a brief examination of these remains the members passed into the next room, where the President expressed the pleasure with which he welcomed the Fellows of the Geological Society and their guests, and asked Mr. Shrubsole to say a few words about the Geological Collection.

Mr. Shrubsole said that although the collection was a small one, an endeavour had been made to illustrate the geology of the country around Reading, and he directed the attention of those present more particularly to the numerous relics of the Stone Age which had been obtained from the Valley of the River Thames in the vicinity of that town.

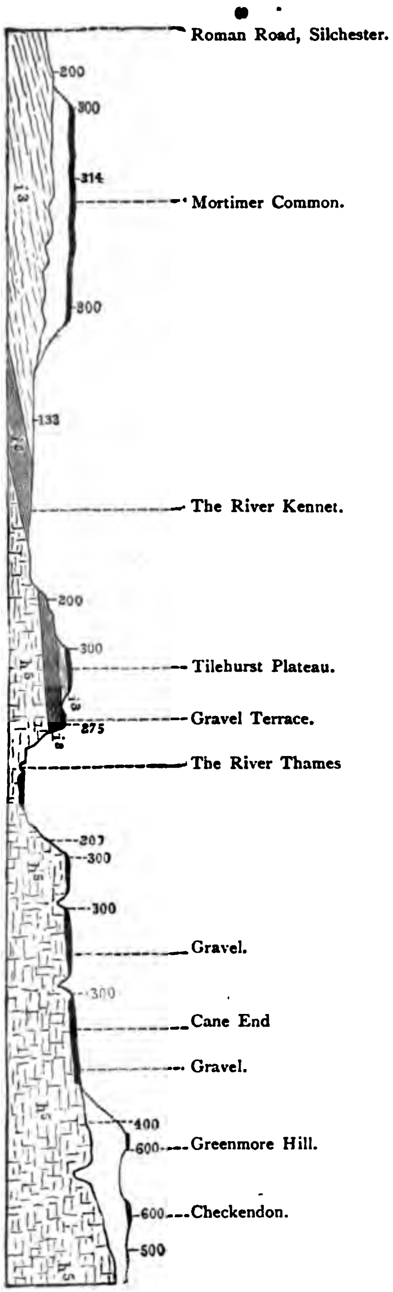

FIG. 23.—SECTION FROM SILCHESTER TO THE CHILTERN HILLS.—*H. W. Monckton.*
(*Reproduced by permission of the Geological Society.*)

i³ London Clay (Ypresian). i² Reading Beds (Upper Landenian). h⁵ Chalk (Senonian).

The figures give the height in feet above the sea.

Horizontal Scale, 2 miles = 1 inch. Vertical Scale, 900 feet = 1 inch.

The line of Section is a little west of Reading. Mortimer Common, Greenmore Hill, and Checkendon are some distance west of the line of section.

For the sake of comparison a series of implements from other localities, including fine specimens from Egypt and India, were exhibited. He remarked that Egypt seemed to have led the way even in Palæolithic times.

The long duration of the Palæolithic stage was shown by the occurrence of implements in stratified gravel at various levels, proving that man had occupied the Thames Valley during a period in which the bed of the river had been excavated more than thirty-five metres. He exhibited an implement which appeared to have been remade from a broken one of a much older date.

A small collection of the rude forms termed Eoliths was also shown. They had been obtained, for the most part, from Plateau Gravels some 120 metres above sea-level, and situated to the east of Reading.

Fossils illustrating the Eocene sections to be visited during the day were distributed among the visitors.

On leaving the Museum the members walked to the brickfields on the eastern bank of the River Kennet, in the southern suburbs of Reading. The working known as the Waterloo Brickfield was first visited, and on arrival there Mr. Monckton gave a short account of the geological succession in the district.

The following is a summary of the series, the beds being given in descending order:

LONDON CLAY (*Ypresian*), which, with a capping of Gravel, forms the top of the hill, but is not shown in the section.

BASEMENT-BED OF THE LONDON CLAY. 3.6 metres thick. *Ditrupa plana*, *Pectunculus* (*Axinæa*) *brevirostris*, etc.

READING BEDS. (*Upper Landenian*):

- i. Variously-coloured mottled Plastic Clays. Thickness about 13 metres.
- ii. Sand with irregular layers of grey clay. Thickness about 6 metres. This is the Reading Plant Bed (compare the *Gelinden Beds*) and is very well shown.
- iii. The bottom-beds of the Reading Series, with *Ostrea bellovacina*, not now exposed here.

CHALK (*Senonian*), not seen but about 5 metres below the floor of the working.

The junction of the Eocene Beds and the Chalk was not to be seen, but Mr. Monckton said that he had often had opportunities of examining it. He believed the top of the Chalk to be a sea-eroded surface. It was often marked with small perforations, possibly due to boring molluscs, or to the roots of seaweed, or to both.

In the clayey bed resting upon the Chalk there were many flints, green externally and not water-worn. Similar stones, which have been termed "green-coated flints," are found in a like position elsewhere, and it has been suggested that they may be due to the underground decay of the Chalk. The question is discussed by Mr. W. Whitaker in his "Geology of London" (*Mem. Geol. Survey*, 1889, vol. i, p. 104). Mr. Monckton remarked that, whether or no this explanation applied elsewhere, it was not applicable here, for the subterranean decomposition of the eroded and bored surface of the Chalk had not been sufficient to produce the result. He looked upon the green coated flints as the relics from the Chalk which had been destroyed before the deposition of the Eocene Beds.

These green-coated flints are, he thought, the local representative of the strata elsewhere laid down during the vast interval which elapsed between the deposition of the Chalk and the formation of the bottom-bed of the Reading Series. Both the top of the Cretaceous and the bottom of the Eocene are absent here.

There is no certain representative of the Danian in England, nor anything corresponding to the Montian of Belgium. The Thanet Sand, a marine formation of some importance on the east of London, thins out towards the west, and comes to an end somewhere between Richmond and Winkfield, probably about thirty-two kilometres to the east of Reading.

Resting upon the Chalk we find a dark-coloured clay interstratified with green sand, and from two to three metres thick. It usually contains one, sometimes two, layers of oyster shells belonging for the most part to *Ostrea bellovacina* and *O. gryphovicina*. The oysters clearly lived on the spot, since their valves are often united and closed. Sharks' teeth occur, and a few marine shells have been found. The "green-coated flints" are in the lowest layer of this bed. (See *Proc. Geol. Assoc.*, vol. xv, p. 305, and Blake and Monckton's "Geology of Reading," *Mem. Geol. Survey*, 1903, p. 27.)

Above the Oyster-bed we find six or more metres of sand with irregular patches and layers of clay. There are no marine remains and we seem to have entered upon a freshwater series.

Leaves and other plant remains abound in some of the lower layers of clay.

A note on these leaves, by Mr. E. T. Newton, will be found on page 40 of the "Memoir on the Geology of Reading," by Messrs. Blake and Monckton. Figures of *Aralia* (?) (*cf. A. looziana*), *Anemia subcretacea*, and *Laurus* (?) are given.

This leaf-bed has also been dealt with by Mr. Starkie Gardner, and a fine specimen of *Taxodium europæum* is figured by him in the "Monograph of the British Eocene Flora" (Palæontographical Society, vol. i, pp. 9, 56, 73; vol. ii, pp. 1, 3, 4, 92, and Plate xxiv).

Mr. Monckton said that he had seen the leaf-bed exposed at several places in and near the Waterloo Kiln workings, and the annexed drawing (Fig. 24) is made from a photograph which he took in 1902.

The section was in a small pit connected with the Waterloo workings and near the River Kennet. The height shown is about two metres; the upper part is sandy, but layers of clay occur and become more and more numerous downwards, showing current-bedding in places. It is in these layers of clay that the leaves are found. Below the leaf bed a current-bedded sand was seen to a depth of over a metre, but it is not shown in the drawing.

On the present occasion the leaf-bed was exposed at the south-west corner of the workings in the Waterloo Pit, and Messrs. Collier and Son, Limited, had kindly caused the face of the section to be cleared for the benefit of the party.

The leaves were not very easy to find—in fact, a vertical face is not suitable for their collection—but sufficient were obtained to show the nature of the deposit.

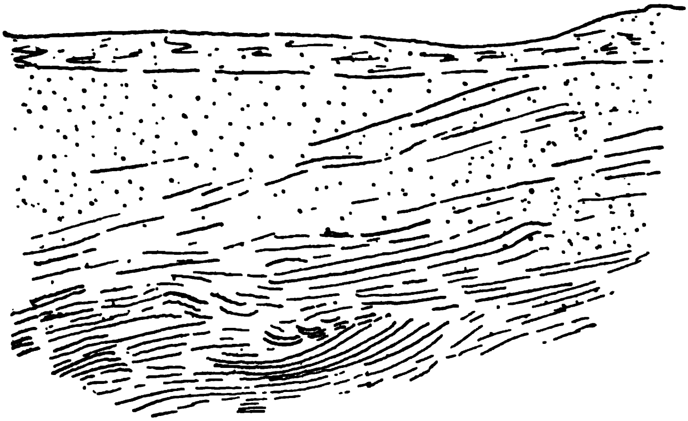

FIG. 24.—SECTION IN THE READING BEDS AT THE WATERLOO KILN, READING, 1902.—*H. W. Monckton.*

The leaf-bed was seen to be overlain by a thick bed, or series of beds, of clay of various colours—the "Mottled Clay" of this part of England. It is about 13 metres thick at this locality, and forms the upper half of the section, the top not being shown in the pit. An analysis of a specimen of the clay obtained in this pit, will be found on page 36 of the "Memoir on the Geology of Reading."

No fossils have been discovered in the Mottled Clay, and it is probably of freshwater origin.

The Estuarine Woolwich Series, of the London District, vanishes as we go westwards, and the most westerly place at which Mr. Monckton had seen it was Guildford, 37 kilometres south-east of Reading.

The bed resting upon the Mottled Clay at Reading is of marine origin, and was termed by Prestwich "The Basement Bed of the London Clay." (*Quart. Journ. Geol. Soc.*, 1854, vol. vi, p. 252.)

The members of the party were able to examine this bed in the old workings of the Katesgrove Pit, a little to the north of the Waterloo Pit. Owing to the fact that the pit is disused, the section was not in a good state for collecting, but the layers of shells were clearly seen. *Ditrupa plana*, *Cytherea tenuistriata*, *Pectunculus* (*Axinæa*) *brevirostris*, are very abundant here. A full list of the fossils obtained from this bed will be found in the "Memoir on the Geology of Reading," p. 50.

The Basement Bed is about three metres thick, and passes upwards into the more purely argillaceous beds, of which the important London Clay formation mainly consists. Mr. Monckton remarked that some years ago the junction was very well shown in a section in this brickfield at right angles to the existing face, and a little north of the spot where the party inspected the shell-bed. The following is from his note book of September, 1881:

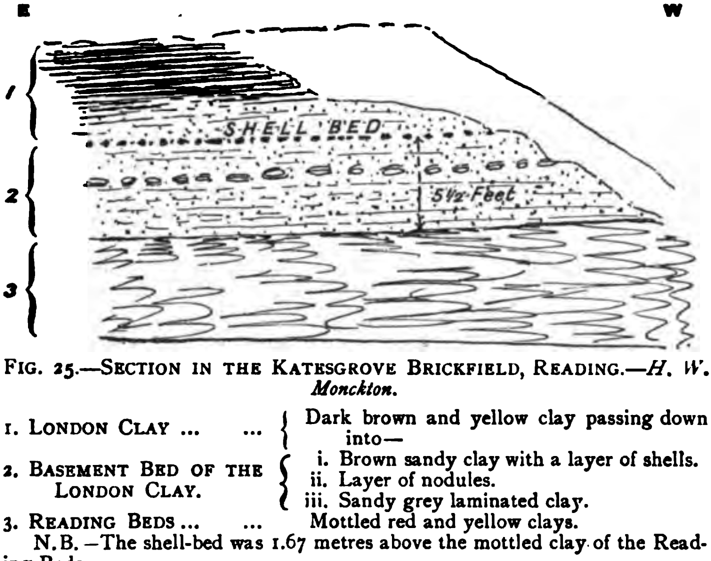

FIG. 25.—SECTION IN THE KATESGROVE BRICKFIELD, READING.—*H. W. Monckton.*

1. LONDON CLAY	Dark brown and yellow clay passing down into—
2. BASEMENT BED OF THE LONDON CLAY.	i. Brown sandy clay with a layer of shells. ii. Layer of nodules. iii. Sandy grey laminated clay.
3. READING BEDS	Mottled red and yellow clays.

N.B.—The shell-bed was 1.67 metres above the mottled clay of the Reading Beds.

There are generally a few flint pebbles in the Basement Bed of the London Clay.

From Katesgrove the party returned to Reading and partook of luncheon at the Hotel McIlroy, in Cheapside; after which they travelled by tramcar to Caversham Bridge, and crossed the River Thames into Oxfordshire.

At Caversham the party was joined by some members who had come from London by a mid-day train. The large chalk-pit close to St. Peter's Church, Caversham, was first visited. The section shows some 21 metres of rather soft white chalk, containing numerous courses of nodular flint and a few layers of the tabular variety.

Mr. Monckton made some observations on the Chalk of the district, and mentioned that a well at Winkfield, about 20 kilometres to the east of Reading, had passed through the whole Chalk formation.

The thickness was found to be :

Upper Chalk	102.7	metres.
Middle Chalk	51.5	"
Lower Chalk	66.7	"
	220.9	

Mr. Osborne White then briefly reviewed the lithological and zonal features of the section under notice. He reminded the members that Prof. Barrois, whom some of them had been fortunate enough to meet in London earlier that week, had described this chalk in his well-known "Recherches sur le Terrain Crétacé supérieur de l'Angleterre et de l'Irlande" (1876, pp. 148, 149).

Prof. Barrois referred the Caversham Chalk, or "*craie de Reading*," to his "*zone à Marsupites*," but at the time he wrote many of the data required for the establishment of a satisfactory zonal classification of the beds of the English Chalk were wanting, and it had remained for Dr. Rowe, nearly a quarter of a century later, to demonstrate the nature and vertical range of the small special fauna associated with the Crinoid *Marsupites testudinarius* in the southern part of this country. This fauna was absent from the Caversham Chalk, which clearly belonged to the upper (but not to the highest) part of the zone of *Micraster cor-anguinum* of recent English authorities, and was probably referable to the zone of *Mortoniceras texanum* of M. de Grossouvre's scheme.

Mr. T. H. Withers then exhibited a selection of the fossils lately obtained by Mr. C. P. Chatwin and himself at this place.

The forms shown included *Conulus albogalerus*, *Epiaster gibbus*, and *Micraster cor-anguinum*. Time did not permit of a close examination of the section, and among the few fossils collected by the members, and shown to Mr. White, there were none of particular interest.

Leaving the chalk-pit, the party walked up St. Peter's Avenue to the top of the gravel-capped plateau on which Toot's Farm stands. This farm is marked on the Geological Map and its name has become well known on account of the large number of Palæolithic implements found there. The level of the plateau at the farm is 71 metres above the sea, and 34 metres above the River Thames at Reading. The ground around Toot's

Farm is being rapidly built over, and the pit from which so many implements were obtained no longer exists, but two other pits on the plateau were visited, from both of which implements have been obtained.

The first of these pits is situated a little to the east of Gravel Hill Cottages. The section showed about three metres of gravel, tolerably well stratified. A seam of small chalk-pebbles was noticed low down in the gravel. Mr. Monckton drew attention to the abundance of pebbles of variously-coloured quartzite which, he said, had in all probability been derived from the Triassic pebble beds of the Birmingham District. That district is now in the drainage area of the River Severn, but he thought that the Severn had captured much of the Thames drainage area since the time of the deposition of the gravels of the Caversham Plateau.

A block of igneous rock was seen in the pit, and it seemed to be very similar to the boulder which he had found in the gravel at the Hockett, near Bisham.*

Some flakes and small implements were found by members of the party in this pit.

The second gravel-pit visited is in Kidmore Road, some distance to the north of Toot's Farm, and rather more than a kilometre distant from the River Thames. A section of gravel about four metres deep was exposed, and signs of the uneven Chalk floor upon which the gravel rests could be seen.

Mr. Shrubsole said that, judging from casual openings, flint implements were pretty generally scattered in the gravel, and occurred in fair abundance to a distance of about a kilometre and a half from the River Thames, and up to the level of the present gravel-pit, about seventy-six metres above the sea. At higher levels implements were rare. It was, he said, interesting to note that in certain of the gravels near Reading at lower levels, say from forty-two to forty-four metres above the sea, implements were not found. As to the implements themselves, he remarked that the later specimens not infrequently show greater rudeness of execution than the earlier ones.

Flakes and worked flints were found by members of the party, and Mr. Shrubsole distributed amongst them some specimens of implements which he had obtained at the locality on previous occasions.

From the Kidmore Road pit the party returned to Reading through Caversham. Mr. Osborne White drew attention to a small cutting which showed from two to three metres of interbedded gravel and brick-earth, lying on the steep side of the valley at a height of some eighteen metres above the River Thames. A worked flint was found *in sitû* here by one of the party.

---

* *Quart. Journ. Geol. Soc.*, 1893, vol. xlix. p. 314.

Tea was obtained at the Hotel McIlroy, after which M. Gustave F. Dollfus, of the Geological Survey of France, speaking in the name of the foreign geologists present, offered his best thanks for the cordial reception given them by the Geologists' Association. He was glad to have made the personal acquaintance of the strata and quarries of the neighbourhood of Reading. These terrains were very similar to those exposed in the environs of Paris. He addressed a very warm invitation to the members of the Geologists' Association to come to Paris and make a similar excursion. In the course of a week he would be able to show to the members a very fine succession of all the strata of the Paris basin, with varied rocks and full of fossils. He offered his best thanks to the Directors of the Excursion, Messrs. Monckton, Shrubsole, and Osborne White, who were so well acquainted with the geology of the district, and had taken so much trouble to make the Excursion a success.

The President (Mr. R. S. Herries), in reply, said that it had given the members of the Association the greatest pleasure to welcome on that occasion so many of the distinguished foreign geologists who had come to England to join in celebrating the centenary of the Geological Society. This excursion was quite of a cosmopolitan character, seeing that they had with them representatives of France, Germany, Holland, Belgium, Denmark and Norway. He was glad to hear that they were pleased with what they had seen, and he particularly wished to thank M. Dollfus, in the name of the Association, for the kind invitation he had given them to visit the Paris Basin, which he would not fail to communicate to the Excursion Committee. He cordially seconded the vote of thanks to the Directors, on behalf of whom Mr. Monckton briefly replied.

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THE MAPS AND DESCRIPTIVE APPENDIX BY C. DAVIES SHERBORN, HON. F.Z.S., AND A NOTE ON CERTAIN SILICEOUS NODULES BY DR. G. T. PRIOR, M.A.

[PLATES VIII. to XXIII. MAPS A—F.]

(Read December 7th, 1906.)

THE WHITE CHALK OF THE ISLE OF WIGHT.

From Compton Bay to Alum Bay, and from Sandown Bay to Whitecliff Bay, with a Zonal Analysis of the Central Chalk Ridge from The Needles to Culver Cliff.

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INTRODUCTION.

LONG before the scattered facts and generalisations of a nascent science had assumed concrete form and crystallised into the rational science of modern geology, the Isle of Wight was famous among amateurs of the curious for its strangely disturbed rocks and for the beauty and abundance of its fossils. It has ever been the paradise of the mere collector, and in later days has become a Mecca to which most English geologists, and not a few of their continental brethren, have been impelled to make at least one pilgrimage; and few there are who once having enjoyed its scenes of beauty and scientific interest can deny themselves the satisfaction of a second visit. Nor is the reason for this fascination far to seek, for compressed within this little island, measuring but twenty-two and a-half miles in one direction and thirteen in the other, is much that is best in English Cretaceous and Tertiary geology. The luxuriant undercliff, the mighty cliff of the Culver with its uptilted strata, the noble vault of the Grand Arch, the rugged promontory of the Needles, and the many-tinted sands of Alum Bay, all long since immortalised in pen and pencil by Englefield and Webster, are enough to make the scenic reputation of a mainland, much more that of a tiny island such as this.

The Isle of Wight exhibits two ranges of hills—the Chalk Ridge, extending from the Needles to the Culver, and the Southern Mass, capped by outliers of the lower beds of the Chalk. We may at once say that we have no concern with the latter, and have not examined them to see if there be any remnant of the basal beds of the White Chalk. The one thing which catches the eye in search of " features " is the characteristic angular scarp of the Greensand in the Southern Mass, forming as it does so graphic a contrast to the rounded contours of the Chalk Downs. The Chalk which we shall examine is, therefore, limited to the Chalk Ridge, the cliff sections of Alum Bay, Scratchell's Bay, Watcombe Bay, Freshwater Bay, and Compton Bay on the west, together with those of Whitecliff Bay, Culver Cliff, and Sandown Bay on the east.

The point which is material when working in the field is that, as we approach the southern edge of the Chalk Ridge, the horizontal strata give place to those which are gently inclined, and that the farther we pass to the north the greater is the inclination of the beds, till when we reach the highest beds of the White Chalk, at the junction with the Eocene, the strata are almost vertical. And so we find that throughout the Chalk Ridge the angle of inclination is always least on the southern side and greatest on the northern side, thus accounting for the fact that the higher beds of the Chalk, usually so soft and easily worked, are if possible harder and more disturbed than the basal beds, which are normally hard and intractable. As a broad generalisation these statements will be found to apply universally throughout the Island, but those who examine the whole of the White Chalk here will find that the stress of upheaval, and consequent compression, has operated unevenly at certain points, thus affording local areas which are relatively soft. The most notable example of this is seen at Alum Bay, at the junction of the Chalk with the Eocene, where the *mucronata*-chalk is so soft that it can be worked with a knife.

The flints, as on the Dorset coast, are often shattered, but they are never so comminuted as in the latter district, where they are often reduced to powder, and drawn out in a long line like a streak of coal dust. And just as the hardness of the Chalk varies within the limits of the same zone, so does the shattering of the flints vary, for there are not a few sections where the flints are quite free from fracture.

A glance at the map (Plate C.) will show that the Chalk Ridge broadens out in the centre to form what we describe as the Central Mass, and the reason for this marked alteration in the configuration of the Down is that there the lower beds of the White Chalk are both somewhat bent and inclined at lower angles than in the eastern and western limbs, thus causing the strata to spread out fan-wise, instead of being compressed within the narrow limits of the more vertical areas. In the eastern and western limbs of the Chalk Ridge the measurement across the Down is often no more than one-third of a mile, that at Afton Down being reduced to one-fourth, whereas the Central Mass is over three miles in width.

Stand on one of the narrower parts of the Chalk Ridge, as at Shalcombe Down, north of Brook, and gaze east and west. Ranging on either side are the noble outlines of the Downs, stretching as far as the eye can see as rolling, billowy masses, such as the Chalk alone can produce. The short, springy turf—the finest surface to walk on in England—is almost their only adornment, save for dwarfed trees of thorn and spindle, and the stretches of gorse aglow with their springtide glory. Here and there, in the hollows of the lower flanks of the Downs, are patches of forest trees, the ranker growth of weed and shrub telling of a thicker soil due to downwash from above.

Turn to the south and look Channel-wards over the hamlet of Brook. Some little distance away from the foot of the Down we see a ridge thrown up in the fields—not rounded like that of the Chalk, but angular. This marks the Chert-beds of the Upper Greensand. Beyond this we have a gently undulating and almost treeless surface, made up of the sandy loams of the Lower Greensand and the stiffer clays of the Wealden. See this on a sunny day in springtime, when the bright green blades are pushing up through the rich, brown-red loam of the Greensand, and we obtain a colour-scheme which is not only a delight to the eye, but eloquent of a bounteous Nature and good husbandry. Speaking of the Chert-beds, there is one ridge on which we walk on our way from Shorwell to Brighstone Down, running parallel with the Down for one-fourth of a mile as straight as the roof-ridge of a house. This is the best landscape feature thrown up by a hard bed which we have seen within the Chalk area of the Island. In the broader parts of the Chalk Ridge, on the southern side of the Downs where the beds are more horizontal, the harder beds of the Greensand form elevations which are nearly always crowned by characteristic clumps of conifers.

Turn now to the north, and we see a complete contrast. The line made by the Chalk and Eocene junction is instant and abrupt, by reason of the *mucronata*-beds being practically vertical, so that right away from the foot of the Down the rich clayey loams of the Tertiaries stretch towards the silvery streak of the

Solent—a fair prospect of noble forest trees and goodly cultivation.

One more view will suffice. Stand on the chalk cliff overlooking Alum Bay on a sunny day and watch the great cliff of Ballard Head flashing back in brilliant whiteness. It does not need much imagination to bridge that narrow arm of sea and join the Island Chalk to that of Dorset.

This paper is, like the others of this series, so entirely zoological in its scope that no place is found therein for a study of the interesting tectonics of the Island. Indeed, these have been handled in so lucid a manner by Mr. Strahan in the *Memoir of the Geological Survey*, entitled "The Geology of the Isle of Wight" (2nd Edition, 1889), that there is no need to traverse old ground. We recommend all those who are working at the Chalk in the Island to read the section devoted to the angular flint gravels in Chapter xiii, the description of disturbances and faults in Chapter xiv, and the summary of the physical geography in Chapter xvi.

We have felt that, in the case of the Isle of Wight, to have kept strictly to the title of our work and confined our observations to the coast would have been a mistake. The consideration of the Chalk Ridge with its 108 quarries and sections has of necessity occupied much space, but it was work which had to be done by someone, and its inclusion makes the survey of the White Chalk of the Island to some extent complete. The examination of the whole area occupied nine weeks, but the essential parts of it can be studied in comfort in as many days; indeed, the chief sections can be traversed in six days, if too much time be not spent in collecting. For the sake of those whose time is limited we give the accompanying scheme:

1. Compton Bay and Pit No. 13, Shalcombe Down.
2. Freshwater Bay, including Pits Nos. 1 and 2, Watcombe Bay, and Alum Bay.
3. Scratchell's Bay (access by boat only).
4. The east side of Culver Cliff, and Pit No. 37 Brading Down, No. 27 Mersley Down, and Nos. 20 and 21 Arreton Down.
5. The west side of Culver Cliff.
6. Pits Nos. 104, 49, and 51 Mount Joy, and No. 77 Brighstone Down.

Though the lists of fossils which we have obtained from the several zones are fairly good, it is only right to say that they are notably weak in forms adnate to echinids and the larger testacea. The intensely hard and adherent nature of the matrix renders any search for these forms almost hopeless. The few which we found owe their detection to weathering alone.

Another point worthy of comment is that in many of the quarries, especially those on the south side of the Downs, the fossils need to be soaked in fresh water to remove the chlorides of sodium and magnesium almost as much as those on the coast.

We found that, after a lapse of some months, the fossils from such sections as Arreton Down and Brading Down were almost destroyed by efflorescence of these salts, some of them, indeed, having broken down into a heap of fine powder. The explanation is that the drift of spray from southerly gales is so strong that the chalk is completely impregnated with salt.

The literature dealing with the Chalk of the Isle of Wight is of considerable volume, but we find it necessary to quote from four works alone, covering the period from 1865 to 1904, and of these one—that by Mr. Whitaker—is frankly pre-zonal. Those who are interested in coast-erosion will find much to interest and admire in Sir Henry Englefield's sumptuous quarto (1816) entitled, "A description of the principal picturesque beauties, antiquities, and geological phenomena of the Isle of Wight, with additional observations on the strata of the island, and their continuation in the adjacent parts of Dorsetshire, by Thomas Webster." A comparison of the splendid drawings of the chief coast sections in the island gives one a retrospect of nearly 100 years.

The works of reference necessary to consult are as follows:

1865. WHITAKER, WILLIAM.—"On the Chalk of the Isle of Wight," *Quart. Journ. Geol. Soc.*, vol. xxi, p. 400.

1875. BARROIS, CHARLES.—"Description Géologique de la Craie de l'Isle de Wight." *Ann. Sci. Géol.*, ser. 4, t. vi, livr. 2, p. 30, Lille, and *Bibl. Ecole Hautes Etudes*, xiii, 1875 (a reprint of which we will quote).

1889. BRISTOW, HENRY W.—"The Geology of the Isle of Wight." Second edition, revised and enlarged, by Clement Reid and Aubrey Strahan. *Mem. Geol. Survey.*

1903. JUKES-BROWNE, A. J.—"The Cretaceous Rocks of Britain," vol. ii; "The Lower and Middle Chalk of England," *Mem. Geol. Survey.*

1904. JUKES-BROWNE, A. J.—"The Cretaceous Rocks of Britain," vol. iii; "The Upper Chalk of England," *Mem. Geol. Survey.*

Mr. Whitaker's contribution, though confessedly non-zonal, is of much interest in that he therein describes the "spurious Chalk Rock" which forms so important a lithological feature near the top of the zone of *Terebratulina gracilis.*

The publication of Dr. Barrois' work immediately produced a profound sensation, for at one blow it swept away the ancient and fallacious regime of a "Chalk with flints" and a "Chalk without flints"—a scheme whose only claim to acceptance was its apparent simplicity, but one which could not stand the test of extended investigation. This treatise was the forerunner of that magnificent classic, the "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," published a year later—a work which not only revolutionised English Chalk Geology, but had an equally far-reaching effect on the study of other formations. Dr. Barrois' conception was philosophical, it was simple, and it was true. Since that date other writers have sub-divided the higher beds into three zones, a division which we have reason to believe entirely meets with Dr. Barrois' approval; but the main scheme of the work remains intact, and stands to-day as it stood then, a work of genius unapproached and unapproachable. This survey of necessity had its limitations, as it was made at high speed and insufficient time was afforded to examine every section completely. When one looks back for 30 years and remembers the number of zonal facts which have accumulated since that date, one is the more profoundly impressed with the fulness of knowledge and accuracy displayed in this pioneer work on the Chalk of the Isle of Wight. All that we have been able to do in addition, with abundant time (nine weeks) at our disposal, is to define the three highest zones and fill in certain gaps in the story.

We have already mentioned the value of Mr. Strahan's chapters on the physical aspects of the subject; but the stratigraphical portion of his part of the revised Survey Memoir is quite unequal to the physical, the author having been content in many cases to quote Dr. Barrois' work *in extenso.*

Mr. Jukes-Browne's memoir is of an entirely different nature. A keen palæontologist, with an unrivalled grip of the stratigraphy of the Cretaceous Rocks, he has given us an account which though necessarily sketchy, from lack of personal familiarity with the Chalk of the Island, is nevertheless substantially accurate. Indeed, none more than ourselves deplore the almost life-long illness which has prevented this brilliant and original writer from participating for so many years in active work in the field. It is safe to say that but for this physical incapacity there would have been no place for "The Zones of the White Chalk of the English Coast," for the whole story would have been told long ago by Mr. Jukes-Browne with a fulness and mastery of detail which would have left little room for further observation. In the case of the Isle of Wight he had received invaluable practical assistance from Mr. William Hill, Mr. C. Griffith, and Mr. R. M. Brydone. Indeed, without the aid afforded by these keen workers it is difficult to see how the portion of the memoirs dealing with the Island could have been written.

COMPTON BAY.

The natural starting point for an examination of the White Chalk is Compton Bay, for its lower beds are here well exposed in a continuous section measuring nearly a thousand yards in length. The bay is always accessible at low tide, but there is one place which must be carefully watched, namely, the projecting point formed by the chert-beds of the Upper Greensand, for here one may be readily caught by the tide. At low spring-tides a good day's work can be done before the returning water reaches the spot, but at neap-tides the time allowed is quite inadequate. It is only at very low spring-tides that access can be obtained to this bay from Freshwater Bay, and the usual course is to take the Military Road, hewn in the south side of Afton Down, to the cliff path west of Compton Chine, which is indicated on the key-plate to Pl. VIII.

The walk along the Military Road is by no means devoid of geological interest, as, starting from Freshwater Gate, we traverse a section in the White Chalk from the zone of *Micraster coranguinum* to that of *Rhynchonella cuvieri*, and it will be noted that the telegraph posts are numbered, thereby giving a useful guide to local features. Further mention of this section will be found on p. 234. The walk along the shore under Freshwater Cliff is not one which we should take for pleasure, for the foreshore is a rugged tumble of large blocks of fallen chalk strongly reminiscent of the doubtful joys of Speeton. Much of the labour of climbing over this rough shore may be obviated in calm weather by taking a boat from Freshwater Bay and landing at low tide on the outer margin of the reefs, or at high tide on one of the rocks which fringe the coast. It can only be done, however, when there is a really smooth sea, and should not be attempted when there is the least swell.

Arriving at the shore we pass over the Gault, Upper Greensand, Glauconitic Marl, Chalk Marl, and the zones of *Holaster subglobosus* and *Actinocamax plenus.* The Belemnite Marls are well displayed in the cliff, and at times on the foreshore, and we had the good fortune to find an example of the name-fossil *in situ*. The Belemnite must be very rare, since it is not recorded in the "Geology of the Isle of Wight" (*Mem. Geol. Survey*), nor in Vol. II of the Cretaceous Memoir. We found it also at Culver Cliff and in Man-o'-War Cove, South Dorset.

Zone of Rhynchonella cuvieri.

The Chalk of this zone is splendidly exposed, and a large amount of it is in good order for collecting purposes—a great contrast to the poor surfaces met with on the Dorset coast. Though there is a belt of hard chalk, gritty in places with fragments of *Inoceramus mytiloides*, there is no true exposure of the Melbourn Rock. The marly seams in the lower part of the zone are rather a conspicuous feature, and it is this part of the bed which we probably see in the seaward faces of New Ditch Point and Oldpepper Rock in our course by boat to Scratchell's Bay. Indeed, we landed on the former rock and proved it to be so. The area where Inoceramus fragments are most developed is about the middle of the zone. The list of fossils is naturally larger than in Dorset, but the fauna fairly corresponds with the normal in this zone, and we shall deal with it in the zonal summary.

There is no feature on the shore to mark the point at which this bed comes to the shore-line, but its situation here corresponds with that of the iron fence which comes down to the cliff edge in a line with telegraph post No. 19 on the Military Road. The junction between this zone and that of *Terebratulina gracilis* is a purely zoological one, and there is again no feature on the shore or on the cliff top to mark its position. At the time of our visit the section of this bed was interrupted by falls from the higher zones, so that it was impossible to give a bed-to-bed measurement in detail. The zone is a flintless one, and measures 84 ft. 7 in. It should be noted that the chalk of this zone weathers out in characteristic manner, hard nodular beds alternating with belts of smoother nature. The junction with the zone of *Actinocamax plenus* is plainly shown, both in the cliff and on the foreshore.

Zone of Terebratulina gracilis.

Here again there is an extensive and, in the main, well-weathered surface for the collector, with a fauna decidedly richer than in the same chalk in South Dorset. The chalk is hard, flintless, veined with marl, and there are the usual marl-bands in addition which weather-out in places as open marl-seams. Besides this there are two curious lines of nodules situated in marl-seams. They are grey or fawn-coloured on the surface, and very white inside, contrasting strongly when broken with the greyer tint of the surrounding matrix. At the first glance we thought that we had met with a course of white flints, for the outlines are irregular and resembling those of a flint, but a blow with the hammer showed that they were no harder than the chalk. The actual nature of these siliceous nodules is described by Dr. G. T. Prior on p. 289. We found them in the same position in the Military Road, Afton Down, in pit No. 13 at Shalcombe, in pit No. 77 at Brighstone Down, and in pit No. 51, near Carisbrooke Castle. Mr. Strahan mentions these nodules on p. 77 of the Isle of Wight Memoir in the following words: "but below the lowest flint there occur nodules of hard siliceous chalk, having the form of flint, but the texture of chalk." In our experience they are unique.

We endeavoured to get a bed-to-bed measurement, but nearly the whole of the lower part of the zone was obscured by a series of falls in 1904. We, however, give measurements of the unobscured upper portion, so that the position of the nodule-beds and of the Chalk Rock of the Geological Survey may be clearly indicated.

In 1903 the second volume of the Geological Survey Memoir on the Cretaceous Rocks of Britain was published, and on pp.

408-410 the author fully confirms our view * that this bed has no claim to be called the Chalk Rock, and that it is situated in the zone of *Terebratulina gracilis.* Now that emphasis has been laid on this point we have no hesitation in using in the present paper the term "spurious Chalk Rock" when we refer to this greenish-yellow nodular band, so that readers of the Dorset paper may know to which bed we refer when we mention the occurrence of this striking and useful lithological feature in the Isle of Wight.

We append the measurements of the upper portion of this zone which alone was capable of being measured in 1904:

	Ft.	In.
"Black marl-band" to "grey marl-band" . .	7	8
Top of "spurious Chalk Rock" to "black marl-band"	5	11
Marl-band to top of "spurious Chalk Rock" . .	7	0
Marl-band to marl-band	3	6
Marl-band to marl-band	8	3
Upper siliceous nodule bed to marl-band . . .	3	3
Lower siliceous nodule bed to upper siliceous nodule-bed	1	9
Marl-band to lower siliceous nodule-bed . . .	3	6
Red sponge bed to marl-band	2	9
Red sponge bed to red sponge bed	2	0
Total	45	7

The total measurement of the *Terebratulina gracilis*-zone is 64 ft. 9 in., so that it is only the lower 19 ft. for which we cannot give details. On p. 413 of Vol. ii of the Cretaceous Memoir, the author gives measurements made by Mr. William Hill in 1897 for the combined zones of *Rhynchonella cuvieri* and *Terebratulina gracilis.* It will be seen that while we give a greater thickness to the zone of *Rhynchonella cuvieri* and a smaller one to that of *Terebratulina gracilis*, our total measurements are practically identical with his.

	Mr. Hill's Measurements.		Our Measurements.	
	Ft.	In.	Ft.	In.
T. gracilis . .	85	7	64	9
R. cuvieri . .	64	0	84	7
Total	149	7	149	4

On referring to our detailed measurement of this zone it will be noticed that we speak of the "black marl-band" and the "grey marl-band." We gladly avail ourselves of the terms used by Mr. Jukes-Browne, as the two marl-bands are important guides in the field. Those, however, who examine the sections in Compton Bay, will look in vain for a black marl-band, for, possibly by reason of bleaching by the salt water, it is only in inland sections that the dark colour is to be seen, and it is equally bleached on the Military Road, Afton Down. We noticed it in pit No. 13 at Shalcombe, in pit No. 19 at Arreton Down, in pit No. 37 at Brading Down, at pit No. 77 at Brighstone Down, and at pit No. 51, near Carisbrooke Castle

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* "White Chalk of the English Coast. Part II, Dorset," *Proc. Geol. Assoc.*, xvii (1), 1901, pp. 46, 47.

It will be seen, therefore, that we coincide with Mr. Jukes-Browne and Mr. William Hill in fixing the junction of the zones of *Terebratulina gracilis* and *Holaster planus* at the second or "grey marl-band" above the "spurious Chalk Rock." Collecting carefully between the "spurious Chalk Rock" and the second or "grey marl-band" above it, we find no evidence of a fauna belonging to the *Holaster planus*-zone, for though *Holaster planus* is as common as in its own zone, and *Micraster cor-bovis* by no means rare, we find no trace of *Echinocorys scutatus*, *Micraster leskei* and *Micraster præcursor*.

Zone of Holaster planus.

We now enter the area of the flinty chalk. To reach a junction of this zone with that of *Terebratulina gracilis* we have to go almost to the extreme western end of the bay before the beds become accessible. At the top of the cliff is a little monument, erected to mark the spot where a child met her death by falling over the cliff. At a point on the shore immediately below this monument the "spurious Chalk Rock" falls to the shore-line, and there is no difficulty in gaining access to the junction of the zones of *Terebratulina gracilis* and *Holaster planus* by climbing. Being more or less out of reach of the waves, the chalk at the junction affords a good surface for collecting.

Directly we pass the second or "grey marl-band" we come upon a bed of *Bicavea rotaformis*, Gregory, the beautiful little rotiform bryozoon which we found in much the same position at Mupe Bay*, where it was 2 ft. thick and occurred 3 ft. above the first or lowest flint course. Here the bed is 6 ft. thick and occupies nearly the whole space between the "grey (or junction) marl-band" and the one above it. Between these two marl-bands the first course of flint occurs, so that the "*Bicavea*-bed" lies partly in flinty and partly in flintless chalk. Professor Gregory's second volume of the "Catalogue of the Cretaceous Bryozoa in the British Museum" has been in manuscript for some time, and we knew that it contained a description of this locally important guide-fossil. So that the title of this bryozoon might be available for quotation in this paper, Professor Gregory has courteously consented to publish a brief diagnosis and indication of distribution. The description will be found in the *Geological Magazine* (Dec. v, vol. iv, No. xi, Oct. 1907, p. 442). Throughout this paper we shall allude to the limited stratum, wherein it is contained, as the "*Bicavea*-bed."

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* *Op. cit.*, Dorset, *Proc. Geol. Assoc.*, xvii (1), 1901, p. 23.

We found no Micraster other than *Micraster cor-bovis* between the junction marl-band and the first flint course, but Mr. Westlake obtained one example of *Echinocorys scutatus* there, so that the zoological and lithological junctions fairly well coincide. We collected *Micraster leskei* and *Micraster præcursor* in the first few feet of flinty chalk.

The fauna of this zone is identical with that of South Dorset, and will be discussed in the Zoological Summary. There is no Chalk Rock in the lithological sense in this zone in the Island, nor did we find any cephalopods or gasteropods, save one fragment of an *Aporrhais.*

The chalk is of a greyish tint, though not so grey as in Dorset, nor is the contrast between the colour of these beds and those of *Micraster cor-testudinarium* so marked as in that county. The flints range from black to grey, with thick white or grey cortices, and they are solid and but little crushed.

Mr. Westlake obtained a measurement in detail of these beds by wading to the recess on the eastern side of the little headland dividing the bays of Compton and Freshwater. The upper beds are displayed in this recess in the same manner as in Freshwater Bay, and the measurement works out as follows. We take the junction of the zones of *Holaster planus* and *Micraster cor-testudinarium* at two marl-bands, 1 ft. 8 in. apart. These are well seen in the tip of the eastern horn of Freshwater Bay, and better still in Watcombe Bay. They pass through the apex of the cave at the western point of Freshwater Bay, and their position is indicated on the key-plates accompanying Plates (IX, X, and XI).

	Ft.	In.
Marl-band to marl-band	1	8
Strong flint tabular to marl-band	1	5
Flint tabular to strong flint tabular	1	8
Thin flint tabular to flint tabular	4	0
Flint course to thin flint tabular	10	6
Marl-band to flint course	10	0
Marl-band to marl-band	8	0
Marl-band to marl-band	12	0
Marl-band (the "grey marl") to marl-band	10	6
Total	59	9

Before leaving Compton Bay it will be well to look back from the western end of the bay so as to note the raking down of the various beds to the shore-line. This is done to best effect after rain and with the sun on the cliff, for then the dark band of the *Actinocamax plenus* marls and the grey tint of the *Holaster planus*-zone contrast strongly with the whiter beds of *Rhynchonella cuvieri* and *Terebratulina gracilis*, and the slightly reddened tint of those of *Micraster cor-testudinarium.* The position of these beds is indicated on the key-plate accompanying (Pl. VIII).

It would be impossible to obtain a list from the *Holaster* *planus*-zone, save for the fortunate accident of many fallen blocks from this bed in the middle of the chalk portion of this bay. There are also fallen masses from the zone of *Micraster cor-testudinarium*, but an examination of the contained Micrasters at once enables one to decide with which zone one is dealing. It will be gathered from what has already been written that it is impossible to work the zone of *Micraster cor-testudinarium in situ*.

FRESHWATER BAY—EAST SIDE.

This bay gives us a range on the eastern side from the zone of *Holaster planus* to that of *Actinocamax quadratus*, and on the western side from the zone of *Holaster planus* to that of *Micraster cor-anguinum*. It is a very unpromising section for the collector, as the two horns of the bay are obscured by seaweed, and the remainder of the chalk is much discoloured by rain-wash from the soil cap. The zone of *Holaster planus* and *Micraster cor-testudinarium* are quite unworkable, as they are clad in seaweed; and but for the fact that we get a clear junction between these beds in Watcombe Bay, some 300 yards to the westward, it would have been quite impossible to have fixed the junction between these zones. By dint of much search we found one example of *Micraster cor-testudinarium* on the eastern side of the bay and two on the western. Only the upper portion of the *Holaster planus*-zone is here exposed, so no measurement is given. The thickness of the *Micraster cor-testudinarium*-zone is estimated to be 52 ft. 9 ins. in Freshwater Bay.

Owing to the Watcombe Bay section we are also able to fix the junctions of the zones of *Micraster cor-testudinarium* and *Micraster cor-anguinum*. The junction between these zones is a purely zoological one, fixed by the zonal variations in *Micraster* and *Echinocorys*, but it fairly well coincides with a marl-band which cuts the southern side of a cave 6½ ft. above the two tabular flint-bands 1 ft. apart. Below the lower of these two tabular flint-bands is a belt of flintless chalk measuring 1 ft. 3 ins. in thickness, which readily catches the eye as a prominent feature in the cliff. The positions of this junction and that of the two marl-bands, 1 ft. 8 ins. apart, which mark the contact of the zones of *Holaster planus* and *Micraster cor-testudinarium*, are clearly indicated on the key-plates to Pls. IX, X, and XI.

Zone of Micraster cor-anguinum.

At the eastern side of the bay, and in Scratchell's Bay, we have the only complete sections of the *Micraster cor-anguinum*-zone at the western end of the Island. We have indicated the position of the lithological junction for the base of the zone, and it only remains to show its upper limits. The measurement obtained for its thickness in this bay is 278 ft. 3 ins., and it will be noticed that it is less by 31 ft. 9 ins. than that recorded for the same zone in Scratchell's Bay. The upper limit of the zone is purely zoological, and is fixed by the occurrence of the first plate of *Uintacrinus*. The chalk is so indifferently displayed in Freshwater Bay that, were it not for the chance of collecting on the pathway leading to Watcombe Bay, and the small cliff-top exposures on East and West High Down, we should have but a very insignificant list to record. The fauna differs in no essential degree from that in Dorset, or indeed from the normal in the South of England, and with the exception that *Micraster* and *Echinocorys* preserve their usual zonal variations, and that *Echinoconus* is present, there is little to add. We have here the usual rather regular courses of flints, together with occasional tabular bands of flint and marl-bands, and the flints are slightly pink towards the surface and have thin cortices. They are more cavernous than in the *Marsupites*-zone, and there is a definite proportion of globular flints among them.

Zone of Marsupites testudinarius.

(i) Uintacrinus-band.

This is, as we have said, but a poor section, for, owing to the dirty nature of the chalk, *Uintacrinus* is by no means an easy fossil to find. Indeed, we have never had to search for it so carefully, save in the wave-battered section under Seaford Head. The *Uintacrinus*-band, so far as we can trace it, measures but 27 ft. in this bay. We have reason to believe that this thickness is slightly less than it should be; still, we give the measurement exactly as it has worked out. The limits of this band are purely zoological, and the difficulty lies not so much with the upper boundary, which is probably correct, as with the lower, where the chalk is much obscured by rain-wash.

(ii) The Marsupites-band.

The *Marsupites*-band is displayed in an equally unsatisfactory manner, and the poorness of the surface possibly leads one to believe that the plates of this crinoid are less abundant than usual. We fix the lower limit of this band at the first *Marsupites* plate, which was found close to the last *Uintacrinus* plate, so that the junction of the two sub-zones is probably quite correct. The junction is entirely zoological, as there is no lithological feature which coincides with it. As is our wont, we fix the upper limit at the last *Marsupites* plate. There is a considerable gap between this plate and the last plate but one, and this probably accounts for the fact that our measurement for the *Marsupites*-band is so greatly in excess of that obtained in Scratchell's Bay. We are inclined to look upon this last plate as a sporadic occurrence, and to attach more belief to the measurement in Scratchell's Bay, which is 43 ft. less than that at Freshwater. *Marsupites* may occur sporadically both above and below its arbitrary limits, and as an example of the latter we quote the record of a nearly complete test of the smooth variety 30 ft. down in the *Uintacrinus*-band at Margate.

The fauna of this zone, though scanty, is eminently characteristic. No belemnites or ammonites were found, and therein this zone coincides with the record in Dorset. The pyramidal shape-variation of *Echinocorys scutatus* was rather common, while *Echinoconus vulgaris* and *Terebratulina rowei* were fairly represented.

The chalk is white and the flint courses numerous, the flints being compact and having thick white cortices. There appears to be the same barren area here, as in Dorset, between the essential fauna of this zone and that of *Actinocamax quadratus*—an area where *Marsupites* dies out and where *Cardiaster pillula* does not come in, but where the transitions in the shape-variations of *Echinocorys scutatus* continue to evolve. Mr. C. Griffith and Mr. R. M. Brydone were the first to discover Marsupite plates here and at Scratchell's Bay, while it has fallen to our lot to be the first to record *Uintacrinus* in all the sections in this zone in the Island.

Zone of Actinocamax quadratus.

We have the good fortune to be able to establish at the head of this bay a short and hitherto unrecorded section of this zone. It is dirty, and the chalk is no longer compact, but broken up into lumps. The flint courses are fairly numerous and the flints are solid, with a pink tinge and thin cortices. That there is no doubt concerning the identity of this chalk may be inferred from the fact that we collected several examples of *Echinocorys scutatus* of the shape-variation characteristic of the lower part of this zone, as well as an example of *Cardiaster pillula*. The name-fossil was not found.

FRESHWATER BAY—WEST SIDE.

If the beds on the eastern side of this bay are unattractive, then those on the western side must be considered as absolutely repellent. It is only possible to work the *Micraster cor-anguinum*-zone, and as we get no junction with the *Uintacrinus*-band, the section is incomplete, and for that reason we have not measured it. The junction of the zones of *Micraster cor-anguinum* and *Micraster cor-testudinarium* are fixed at the same marl-band, 6½ ft. above a tabular band of flint. On the opposite side of the bay there were two flint tabular bands 1 foot apart, but here one is lost—an excellent instance of the unreliability of lithological features even within a limited area. The junction of zones of *Micraster cor-testudinarium* and *Holaster planus* is seen in the apex of the cave at the western horn of the bay, and both these junctions are accurately indicated on the key-plate which accompanies Pl. X. It will be noticed that the base of the seaward surface of the Arched Rock is faced by the zone of *Holaster planus*, while the whole of the Stag Rock is cut in the zone of *Micraster cor-testudinarium*. This is indicated on Pl. A.

WATCOMBE BAY.

Here we have a small, but beautifully weathered section embracing the whole thickness of the zone of *Micraster cor-testudinarium* and part of the beds belonging to those of *Micraster cor-anguinum* and *Holaster planus*.

Zone of Micraster cor-anguinum.

There is a practicable pathway leading to the beach, cut entirely in the zone of *Micraster cor-anguinum*, and yielding the best list of fossils obtainable in this zone in the whole island. Indeed, we have here the only chance of obtaining a knowledge of the basal fauna of this zone, for this horizon is dirty and overgrown with seaweed at Freshwater Bay and Culver Cliff, and pounded by the shingle at Scratchell's Bay. It will be seen that lithologically, as in Sussex, the lowest beds are rugged and iron-stained, thereby resembling in appearance the zone immediately below. In striking contrast to the rather barren nature of this horizon at St. Margaret's Bay, near Dover, we find a rich fauna passing right down to the junction and blending imperceptibly with that of the zone of *Micraster cor-testudinarium*. In point of fact, but for the presence of *Micraster* and *Echinocorys*, we could not have separated the base of one zone from the top of the other. *Micraster*, however, though not abundant, gave ample evidence of the zone, for though the ambulacra were "sub-divided," as in the zone of *Micraster cor-testudinarium*, the periplastronal area was decidedly mammillated. Further, the few examples of *Echinocorys* which we obtained presented an undoubted affinity to the shape-variations characteristic of the *Micraster cor-anguinum*-zone. We did not find *Echinoconus* *vulgaris* in this section, but it was rather common in the exposures on the cliff edge along High Down.

The lithological junction is fixed for convenience at the same marl-band which we have alluded to on the eastern and western sides of Freshwater Bay, as having a tabular flint band 6½ ft. below it with a belt of flintless chalk 1 ft. 3 in. thick beneath. As in the western side of Freshwater Bay, one of the pair of flint tabulars is missing. The junction marl-band is found in the lowest shelf of the pathway leading to the beach, and can be traced into the fissure on the east side of the pathway. The actual zoological junction occurs 3½ ft. above the marl-band, but we prefer to adopt thc latter as it is easily followed as a guide, and is sufficiently exact for all practical purposes.

Zone of Micraster cor-testudinarium.

We append the detailed measurements of this zone which are taken from the upper of the paired marl-bands, 1 ft. 8 in. apart, already utilised on both sides of Freshwater Bay.

	Ft.	In.
Thin flint tabular to marl-band	6	6
Thick flint tabular to thin flint tabular . . .	1	0
Thick flint tabular	0	2
Flintless band of chalk	1	3
Marl-band to base of flintless band of chalk . .	1	4
Marl-band to marl-band	6	0
Flint course to marl-band	8	0
Bedding plane to flint course	3	6
Bedding plane to bedding plane	8	4
Marl-band to bedding plane	2	0
Flint course to marl-band	3	10
Upper of paired marl-bands to flint course . . .	8	6
Total . .	50	5

The general appearance of the chalk of this zone fairly well conforms to that of others at the same horizon, but it agrees with the same bed in Dorset in that it is rather less rugged and nodular than usual. In Dorset this chalk was notably red from diffused iron staining, forming thus a strong contrast to the grey beds of the *Holaster planus*-zone. Naturally, the distinction is not so marked here. The flints are black and solid, and have thin white cortices. There are many beds of marl in this zone.

The fauna is rich and thoroughly representative. *Micraster* is sufficiently abundant to be an unfailing guide, and, as in Dorset, the broad form known as *Micraster cor-testudinarium* is notably in excess of the narrower group-form known as *Micraster præcursor*. The gibbous form of *Echinocorys scutatus* is fairly common, and the bryozoa are alike numerous and characteristic.

Zone of Holaster planus.

By climbing on to the top of the big fallen masses which here form the point on the eastern side of this bay we can get a thoroughly representative list of fossils from this zone. *Micraster* is sufficiently common to give us all the data that we require to fix the dividing line between this zone and the one above it. Just above the paired marl-bands we found two examples of *Micraster præcursor* with "gently inflated" ambulacral areas, and below the junction-line forms with typical "sutured" ambulacra were obtained. The section is so small that we do not describe it in greater detail, but it is quite sufficient to afford an accurate junction-line between this zone and the one immediately above it.

THE COAST FROM FRESHWATER BAY TO SCRATCHELL'S BAY.

From Watcombe Bay to Scratchell's Bay there are no inlets, but there are numerous falls all along the section, and in one or two places a small beach is seen, notably at a spot called Roe's Hall, to the east of Oldpepper Rock. On a smooth day, when there is no swell, the boatmen will land one at any of these points, and excellent collecting may be obtained from the zone of *Terebratulina gracilis* to that of *Micraster cor-anguinum.*

The journey by boat to Scratchell's Bay is most instructive and quite essential to a knowledge of the structure of the cliffs. Two conditions dominate the range of beds exposed. The first is the altitude of the cliff, and the second is the degree in which the cliffs recede to the north or advance to the south. The two most projecting points (shown on the key-plate to Pl. X) are New Ditch Point and Oldpepper Rock, and here, as we should naturally expect, we get the greatest zonal range, extending from the lower part of the zone of *Rhynchonella cuvieri* to the higher beds of the zone of *Micraster cor-anguinum.* On the other hand, wherever the cliffs recede to the north, or are of small altitude, the zonal range at once decreases. Instances which readily occur are seen at Bar Cave, where the cliff is low, and at the Kitchen, where the cliffs, though high, are almost vertical. In both instances the only zones exposed are those of *Micraster cor-testudinarium* and *Micraster cor-anguinum.* The same thing occurs at Preston's Bower. A view of the coast from the sea makes it abundantly clear why we should find nothing but the zone of *Micraster cor-anguinum* at the top of the cliff. We know the zone to be some 300 ft. thick, so that the whole thickness of the beds is traversed as we pass from end to end of the section. The highest point of the cliff is at Tennyson's Beacon, where it reaches 483 ft. Here, if anywhere, we should seek for the *Marsupites*-zone, and later on we shall show that we found *Uintacrinus* at this point.

SCRATCHELL'S BAY.

We now reach this fine bay with the Needles and Grand Arch. It may be mentioned that one can get there only by boat, and that owing to the strong currents at the Needles it is much easier to approach it from Freshwater than from Alum Bay. There are two natural falls in this bay, and one talus of chalk tipped from above. The tip was made when the fort was being excavated, and together with the fall in the centre of the bay is in the zone of *Actinocamax quadratus*, while the old fall by the Needles is wholly in the zone of *Belemnitella mucronata*. This fall was caused by the concussion from the heavy guns of the Needles fort.

As we round Sun Corner in the boat the eye is at once arrested by the wonderful sweep of the beds in the Grand Arch, and the crowded flint lines above the grass slope on the projecting point of the bay. Obviously, the chalk below the grass slope is in the zone of *Micraster cor-testudinarium*, and we now seek a junction with the zone above it. Fifteen feet above the grass slope is a single strong tabular flint-band with a narrow belt of flintless chalk below it; but no marl-band can be seen 6½ ft. above the tabular band. We can find no better junction than this in an accessible surface, and we can only once more point out what feeble reeds to lean on are these long trusted lithological features. The zone of *Micraster cor-testudinarium* seems to be about 50 ft. thick, and is inaccessible in its entire extent. Mr. Strahan (*op. cit.* p. 75) says that "the brow of the cliff known as the Main Bench, which is vertical and descends sheer into the water, was determined by the Ordnance Survey to be 416 ft. above the datum-level, while the Grand Arch, which forms the east side of Scratchell's Bay, and overhangs considerably, is 300 ft. in height."

Attractive as these cliffs are from the sea they afford but poor sport for the collector. Indeed, but for the fall in *mucronata*-chalk, few fossils would ever leave this bay, for the surface is planed off smooth by the action of wave and shingle, and unless one can climb up some feet, the chance of finding fossils is remote indeed.

Zone of Micraster cor-anguinum.

We take the strong tabular flint line some 15 ft. above the grass slope as the approximate base-line for this zone, and obtain the measurements of the lowest beds by using a boat. The upper limit is fixed by the occurrence of the first *Uintacrinus* plate, and may be taken to be reasonably accurate, as there is no difficulty in finding the plates of the crinoid in this section. The measurement obtained for this zone is 310 ft., but no detailed section is given. The measurement was plotted out in sections according to the dip, and each section worked out separately. To look for any fossil save *Micraster cor-anguinum*, *Echinocorys scutatus*, *Echinoconus conicus*, and *Porosphæra* in a shingle-battered section like this is sheer waste of time. These we obtained, and found them to be fully characteristic of the zone.

Zone of Marsupites testudinarius.

(i) Uintacrinus-band.

Happily, here the cliff is set back a little, and for that reason is not so pounded by the shingle. The chalk is hard and white, and flint courses are common, the flints themselves being solid and black, with thin white cortices. We have long since abandoned the hope of finding any reliable zonal guide in the flints of this district. The same horizon at Freshwater Bay yielded flints with a thick pinkish cortex, and we could multiply the evidence *ad nauseam* throughout the zones in the Island.

We fix the junction with the zone of *Micraster cor-anguinum* at the position of the first *Uintacrinus* plate, and the upper limit of the sub-zone by the presence of the first *Marsupites* plate. We believe that both these junctions are substantially accurate, and that the thickness given here, 34 ft. 6 in., is a much more reliable guide than that at Freshwater Bay. There are no salient lithological features to coincide with the zoological junctions.

(ii) Marsupites-band.

Both chalk and flints are of the same nature as those described in the *Uintacrinus*-band. We fix the upper limit of the zone at the position of the last *Marsupites* plate, but no close zoological junction could be obtained here for the simple reason that *Cardiaster pillula*, and still more *Actinocamax quadratus*, appear to be rare fossils in this bay. We found the former, however, about 20 ft. higher up, so that this junction conforms to all others which we have described. In any case *Marsupites* is in itself a sufficient guide, and we are quite content to establish the upper boundary of the zone by its presence alone.

The description of the junction of the zone of *Marsupites testudinarius* and *Actinocamax quadratus* at the Culver (p. 245) deals with the conspicuous belt of flintless chalk associated with the remarkable red-green nodule beds. It will be seen (p. 244) that the lowest of these nodule beds is in the *Marsupites*-band. At the same position in Scratchell's Bay we search in vain for these features. It is true that for a space of about 20 ft. the chalk at this point is relatively less flinty than in the beds above and below it, but there is no warrant whatsoever for Mr. Jukes-Browne's statement* that the *Marsupites*-zone is characterised by a scarcity of flints, for both the sub-zones are crowded with flint courses. Mr. Jukes-Browne does not even allude to the sub-zone of *Uintacrinus* in the Isle of Wight.

We obtain a measurement of 47 ft. for the *Marsupites*-band, and this, coupled with the 34 ft. 6 in. of *Uintacrinus*-chalk, gives a total of 81 ft. 6. in for the whole zone. We believe this to be a much more accurate measurement than that given at Freshwater Bay. The credit of being the first to find this section of the *Marsupites*-band belongs to Mr. C. Griffith and Mr. R. M. Brydone; while here, as elsewhere in the Island, we are the first to establish the occurrence of *Uintacrinus*.

Neither *Marsupites* nor *Uintacrinus* can be said to be abundant here, but they are sufficiently conspicuous to make it a source of wonder that their existence has been so long undetected. The associated fauna is, however, alike sufficient and characteristic, for in both sub-zones we obtained the typical pyramidal shape-variation of *Echinocorys scutatus*, *Terebratulina rowei*, and the nipple-shaped head of *Bourgueticrinus*. *Echinoconus vulgaris* was also found, but no trace of ammonites or belemnites. There is no band of *Echinocorys* or *Echinoconus* as at Margate.

Zone of Actinocamax quadratus.

The remainder of the actual cliff face, as shown on the beach, to within ten paces of the big fall in *mucronata*-chalk, is in the zone of *Actinocamax quadratus*. The chalk is rather white and hard, seamed with flint courses, with a marl-band here and there, while the chalk itself is veined with marl, which gives it a decidedly greyer tint than that seen in the white *mucronata*-beds. This distinction is of decided utility in the field. The flints are black, with thin white cortices.

It would be difficult to imagine a more unpromising section for fossils than this, for *Echinocorys* is only seen in section, and even *Porosphæra* is planed off flat. We removed all the examples of *Echinocorys* which we saw in section in the cliff, and had no difficulty in referring them to the *quadratus*-chalk. The whole section yielded only two examples of *Actinocamax quadratus*, one of *Actinocamax granulatus*, and twelve of *Cardiaster pillula*.

Our work on the Dorset coast prepared us for a possible rarity of the name-fossil, for there we found it only in a band 15 ft. thick, in the middle of the zone, in the horizontal chalk at West Bottom, near White Nothe. Convert this horizontal into vertical chalk, and it will at once be evident how easy it might be to miss the belemnite in one restricted belt a few feet only in width. *Cardiaster pillula*, on the other hand, was fairly common in Dorset, even in the vertical chalk, and this makes its comparative rarity here the more remarkable.

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* *Mem. Geol. Surv.*, Cret., vol. iii, p. 92.

The measurement obtained for this zone is 343 ft., and the zonal contacts are purely zoological, being taken from the highest *Marsupites* plate to first example of *Belemnitella mucronata.* There are no lithological features which coincide with these two points. We own that at first we expected a greater thickness for this zone, but Mr. Westlake took such pains to get accurate data that we are only too willing to accept it as correct.

Immediately to the north-west of the fall in *quadratus*-chalk we notice a conspicuous feature. It is well up in the *quadratus*-zone, and consists of a band of flintless chalk, some 4 ft. thick, which sweeps down to the shore in a bold curve from the iron palisade of the fort. Associated with it are two ordinary thin red sponge-beds 5 ft. apart. They are not in the same position as the nodule-beds at the Culver, and must not be confounded with that remarkable feature. The bed which we have just described does not exist at Culver Cliff.

Zone of Belemnitella mucronata.

It is a relief to pass from the barren *quadratus*-chalk to a zone which has a fauna at once abundant and distinctive. The chalk is still hard and flint courses are numerous, some of the individual masses being very large. The colour of the flints varies from black to a rich umber, and the cortices are thin and white, though in the case of those of umber tint the crust is of a fawn colour. Sometimes in other sections of this zone the flints are smoke-grey in tint, but they are rarely of the same colour in two consecutive sections.

We fix our contact with the zone of *Actinocamax quadratus* by the presence of the lowest *Belemnitella mucronata*, and as it was found within one foot of an example of the small pyramidal *Echinocorys*, which is so characteristic of the horizon in question, we had no scruple in taking this as the base-line of the zone. The junction is entirely zoological, as we find no lithological feature sufficiently distinctive to use for this purpose.

Belemnitella mucronata cannot be said to be an abundant fossil here, and is not nearly so common as at Ballard Head or Studland Bay, though it is perhaps rather more frequently found in the higher beds in Alum Bay. *Echinocorys* is really a common fossil, especially the small pyramidal shape-variation, which resembles the pointed form of *Echinoconus conicus* in profile. In addition to these large and easily seen guide-fossils we can always rely on the spines of *Cidaris serrata* and on *Crania* *costata*. *Magas*, here as elsewhere, peculiar to this zone, is a gregarious fossil, and when found is usually abundant and all-sufficient as a guide; but in this island it would appear to be very uneven in its distribution, occurring only in the top of the zone. The bryozoa, which are singularly abundant, are also useful in forming a zonal determination.

ALUM BAY.

The junction of the *mucronata*-chalk with the Tertiaries is well worth seeing, for it affords a remarkable example of an eroded surface of pre-Tertiary age.* On the occasion of our visit we had to wait for the tide, and occupied the time very profitably by breaking up the blocks which had fallen at the junction with the Tertiaries. The chalk at this point is quite soft and can be readily trimmed with a knife. *Magas pumilus* is here quite abundant. One can walk out to the Needles at low tide, but the results hardly justify the labour, as, owing to the sheared surfaces of rock, which are all cut along the bedding-planes, the fossils are not well preserved, while even the falls yield but a poor fauna. It is instructive to examine this section at a really low tide, for then the extent of the chalk reefs gives one some idea of the thickness of the *mucronata*-zone.

The famous Needles are wedge-shaped rocks of *mucronata*-chalk which have resisted marine and aërial erosion to a surprising degree. As we traverse the *mucronata*-chalk in Scratchell's Bay it becomes evident that an increasing degree of induration is met with as we approach the Needles, and this reaches its maximum at the southern surface of the shoreward Needle. Indeed, the chalk is here so hard that it is almost impossible to remove a fossil from it, and herein unquestionably lies the explanation of the formation and persistence of these famous pinnacles. The Needles run out a little south of west, following the almost straight westerly trend of the beds in Alum Bay. Mr. Strahan tells us† that "a lofty spire of chalk, which once rose as the most conspicuous of the group, fell down in 1764. A base of 60 ft. in diameter has been levelled on one of them for the foundations of the lighthouse, which was removed to it in 1858 from High Down, where it originally stood."

The thickness of the *mucronata*-chalk is greater than that hitherto recorded for any section of the zone, for it yielded the big measurement of 475 ft. It will be remembered that at Ballard Head we had a thickness for the bed of 250 ft., but that this did not take into consideration any portion of this zone south of the thrust-fault, where the chalk was inaccessible. The measurement is made up as follows:

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* Mr. Whitaker (*op. cit.*) denies this, and states that it is analogous to the well-known pipes at the surface of the chalk, and that it is due to the solution of the surface of the chalk after the Eocene series had been deposited. See also "Isle of Wight Memoir," Fig. 16, p. 95.

† *Mem. Geol. Survey*, I. of Wight, p. 73.

In Scratchell's Bay, from junction with *quadratus*-chalk to Needles	196 ft.
Thickness of shoreward Needle	52 ft.
In Alum Bay to junction with the Tertiaries . . .	227 ft.
TOTAL	475 ft.

THE CLIFF EDGE FROM FRESHWATER BAY TO SCRATCHELL'S BAY.

The walk on the south side of High Down should be taken after the section has been viewed from the sea (p. 227). Suffice it to say that the whole of the exposed surfaces along the cliff edge from Freshwater to Sun Corner, with the exception of the little exposure of *Uintacrinus*-chalk at the Tennyson Beacon, are in the zone of *Micraster cor-anguinum*. Here and there along the cliff top we get well weathered and accessible surfaces which repay the collector. There are at least two paths down the cliff which might result in good air-weathered surfaces. We did not try them.

At Tennyson's Beacon the cliff is 483 ft. high, and it is this considerable addition to the altitude which gives us the little exposure in *Uintacrinus*-chalk. The monument itself must stand on the *Marsupites*-band. Like most of the other good things in the chalk of the Island the section was first discovered by Mr. C. Griffith and Mr. R. M. Brydone, for the former writes that he found brachials of *Uintacrinus* or *Marsupites* at this spot. We obtained a list of sixteen species there, including a number of plates of *Uintacrinus*, and three examples of *Terebratulina rowei*, but no evidence of *Marsupites* was forthcoming.

On p. 91 of Vol. III of the *Geological Survey Memoir of the Cretaceous Rocks* we have the curious statement that fossils from the *Micraster cor-anguinum*-zone have been collected from five or six pits along the top of the cliffs between Freshwater and Scratchell's Bay. There are no pits along the south side of High Down, and the writer must evidently refer to the little exposures along the edge of the cliff.

The edge of the cliff at Scratchell's Bay is also well worth a visit. At the highest point, by the southern palisade of the fort, we found *Cardiaster pillula*, and lower down the slope where the grass is worn away we successively meet with the fauna of the *Marsupites* and *Uintacrinus*-bands and the *Micraster cor-anguinum*-zone. The end of the palisade is a useful guide when one is on the shore in the bay, as immediately under it is a flintless belt of chalk which can be traced in its sweep down to the point a few yards south-west of the cement platform on the beach. It gives one a useful line as to the point at which one may begin to search for the highest *Marsupites* plates. When the fort was being excavated Mr. Griffith and Mr. Brydone found an ample *quadratus* fauna there, including numerous examples of *Cardiaster pillula.*

THE OLD ROAD AT FRESHWATER BAY.

The position of the abandoned sea-road on the east side of Freshwater Bay is indicated on Pl. IX, and is shown on the 6-in. map, while its truncated end can be seen from the beach. The cliff has been cut back through it for many years. It gives an admirable line for the position of the *Uintacrinus*-band in the cliff, for on its northern side is a shallow bank-exposure of surface chalk, and in it we found plates and brachials of *Uintacrinus* and three examples of *Terebratulina rowei.* At its extreme seaward limit we found one plate of *Marsupites.*

THE MILITARY ROAD, FRESHWATER.

Time was when this section afforded opportunities for good collecting, but now it is lichen-clad and black with age. The road is joined to the west of Compton Chine by a track passing obliquely up to join the Roman Road on the summit of East Afton Down, the position of the track being indicated on our map. The point mentioned is a few yards to the east of the telegraph post, No. 26. At the junction with the track over the Down we find the zone of *Rhynchonella cuvieri* exposed, and obtain the name-fossil and *Inoceramus mytiloides.* We fix the junction between this zone and that of *Terebratulina gracilis* between telegraph posts 25 and 26. Fossils are very scarce in the *gracilis*-beds, but we collected the name-fossil, *Pentacrinus agassizi* and *Terebratula semiglobosa.* We here found the siliceous nodules which form so remarkable a feature on the shore (p. 218). At telegraph post 25 the "spurious Chalk Rock" sinks to the level of the road, and we fix the junction of the zones of *Terebratulina gracilis* and *Holaster planus* at the second marl-band above the "spurious Chalk Rock," as on the shore. The marl-band immediately below this is the layer of black marl originally described by Dr. Barrois* and subsequently noted by Mr. Jukes-Browne. This "black marl-band," though doubtless of that colour when the road was first cut, is now, by reason of contact with the spray-laden winds, not different in colour to any of the other marl-bands in the section. The junction marl-band falls to the level of the road between the telegraph posts 24 and 25, but nearer to the former. We found the distinctive bryozoon, *Bicavea rotaformis*, in the same position as on the shore, both in the flinty and flintless chalk. The section yielded a fair list, including *Holaster planus*, *Micraster cor-bovis*, *Micraster leskei*, *Micraster præcursor*, *Echinocorys scutatus* var. *gibbus*, *Hemiaster minimus*, *Pentacrinus agassizi*, *Terebratula carnea*, *Rhynchonella plicatilis* and *Rhynchonella cuvieri*.

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* *Bibl. Ecole Hautes Etudes*, xiii, 1875, p. 19.

The contact between the zones of *Holaster planus* and *Micraster cor-testudinarium* is found at the marl-band which cuts the road-line thirty-two paces west of telegraph post No. 24. There are here seen two marl-bands, but they look more than 1½ ft. apart, as at Watcombe Bay. *Micraster cor-testudinarium*, *Micraster præcursor*, and *Echinocorys scutatus* var. *gibbus* were here collected.

We obtain a junction between the zones of *Micraster cor-testudinarium* and *Micraster cor-anguinum* by finding the marl-band 6½ ft. above the first of the paired tabular flint bands, and we trace this marl-band to the level of the road at a spot twenty-seven paces west of telegraph post No. 22.

The remainder of the western end of this road section is cut in the zone of *Micraster cor-anguinum*, for we carefully examined it from telegraph post No. 17 to the end of the exposure, and failed to find any trace of *Uintacrinus*. We, however, collected *Micraster cor-anguinum*, *Echinoconus vulgaris*, and the characteristic shape-variation of *Echinocorys*.

It would have been impossible to have attempted to zone this section without the aid of *Micraster*. By careful collecting we obtained thirty examples of this urchin, and were enabled not only to demonstrate the typical zonal forms, but also the passage forms linking up the facies of the several zones.

Dr. Barrois (*op. cit.* p. 22), Mr. Strahan (*op. cit.* p. 82), and Mr. Jukes-Browne (*op. cit.* vol. iii, p. 90) give a description of this section, the two latter with detailed measurements, and Dr. Barrois and Mr. Jukes-Browne with diagrams; but none of them have made an attempt to define the boundaries of the zones by zoological data.

The position of the Military Road is indicated in the upper division of Pl. B. by the telegraph posts, which are numbered from fourteen to twenty-seven. The position of several of these posts in relation to the zones does not correspond with our description in the text. As the actual posts are numbered, no difficulty on this score will arise in the field.

CULVER CLIFF.

It is well to state that, to all intents and purposes, the extreme southern point of the Culver, at the Nostrils, is inaccessible on foot from Sandown Bay. The boatmen tell us that, in point of fact, there are about ten occasions in the year when the headland can be passed on foot, but to do that there must be no onshore wind and the sea must be quiet. One can land at the Nostrils on a calm day, but the boatmen will not do so if any swell exists. Except for this extreme point, the whole of the section from Sandown Bay to Whitecliff Bay may readily be examined at low tide; but to investigate the Nostrils section in comfort a really low tide should be chosen, as this will obviate the necessity for climbing over steep and seaweed-covered rocks.

For ease in reference we divide the Culver into the Southern Cliff, which extends from Sandown Bay to the southern side of the Nostrils; the Eastern Cliff, which takes in that portion from the Nostrils to the south-east corner of Whitecliff Bay; and the White Cliff, which is seen only in Whitecliff Bay.

On Culver Down.

The walk over the top of Culver Down is interesting, though by no means so instructive as that from Freshwater to the Needles. Numerous small patches at the cliff edge, and slipped faces further back, give an indication of the zone. Practically all these surfaces on the Southern Cliff, as far as the White Horse, are in the zone of *Micraster cor-anguinum*. It will be remembered that the same thing occurred all along High Down, from Freshwater to Sun Corner, and the reason for this is obvious when we examine the section from a boat. Quite recently a Marconigraph station has been erected to the south of the Earl of Yarborough's monument, and in front of it is a large heap of chalk tipped from the excavations for the same. An examination of the chalk yielded several plates of *Marsupites*. If the eye be carried from this building to the position of Bembridge Fort, and thence to pit No. 40, an excellent line will be obtained for the position of the *Marsupites*-zone. A reference to the section of the paper devoted to the pits (p. 259), will show that part of the chalk tipped from the excavation for Bembridge Fort is found in pit No. 15. The wire cables which we see on the shore are the earth-cables of the Marconigraph.

The War Office has taken over the whole of the end of the chalk Down overlooking Whitecliff Bay, and the remainder of the Head almost up to the Marconigraph station; so that in the near future this area will be incapable of examination. A trench has been cut from a point south of the semaphore in a south-easterly direction to the cliff edge. At the upper part of this trench the two pairs of greenish-red nodule-beds, which are such a conspicuous feature on the shore, are seen associated with the two tabular bands of flint and the four marl-seams. Among the upper nodule-beds we found two perfect examples of *Echinocorys scutatus* of the shape-variation distinctive of the *Actinocamax quadratus*-zone; while at the seaward end of the trench we collected an example of *Echinocorys* of the shape-variation belonging to the *Micraster cor-anguinum*-zone, *Echinoconus vulgaris*, and *Micraster cor-anguinum*. The trench extends, therefore, from the *Micraster cor-anguinum*-zone to that of *Actinocamax quadratus*. We examined the intermediate chalk for plates of *Marsupites* and *Uintacrinus*, but without result, for the reason that the trench was so recent that weathering had not yet had time to take place. We also searched the cliff edge for *Uintacrinus*, but there were no bare spots where that fossil should appear; while, in any case, it is doubtful if the cliff is high enough to take in the whole thickness of the zone of *Micraster cor-anguinum*.

Some useful collecting in the zone of *Micraster cor-anguinum* may be obtained in the bare surfaces at the cliff edge, and we would particularly mention one broad surface leading down to a path hewn behind the ledge to the Hermit's Hole, which is a cave in the upper part of the cliff. Those who utilise this narrow path should remember that sheep often stray down it. The boatmen tell us that this fact bears with it an unexpected danger, for the sheep, frightened by the sound of footsteps, will rush up the path and would readily thrust a man over the edge into the sea. They say that the course which they invariably adopt is to open the legs wide and to allow the sheep to get past in that way. There is a footpath to the shore at Whitecliff Bay, which passes over the junction of the Chalk with the Tertiaries, a fact of which one hardly needs to be reminded when making the descent on a wet day. We can also reach this bay from Sandown by taking the road through Yaverland and then striking the footpath which skirts the northern side of the Down.

THE CULVER SECTION.

We take the beds in ascending order as they are exposed in the Southern Cliff, the Eastern Cliff, and in the White Cliff. The section can be reached by walking along the shore from Sandown, or by following the cliff path until a point is reached some 250 yards west of the base-line of the chalk on our map, where there is a path to the shore over the Greensand. Arriving on the shore we note that there is a boss of Upper Greensand, which projects from the cliff, with a deep gully in it. This feature is worth noting, as it is there that one may readily be caught by the tide. An exactly similar Greensand obstruction exists at Compton Bay, and we have had to wait there for two hours while the beach beyond was lying high and dry. Passing over a fine exposure of Chalk Marl and Grey Chalk with ledges of the same running out in trough-like reefs, we reach a good section of the *Actinocamax plenus*-marls. Though, according to the Geological Survey Memoir, they are not supposed to contain the belemnite, we found one, together with a tooth of *Ptychodus decurrens*. At this point our work begins.

With the data obtained at the west end of the island fresh in mind, it will be well to make a rapid traverse of the section on foot as far as the tide will allow us to go, and to the information gained by that means add the clearer perspective gained by viewing it from a boat.

Starting from the *plenus*-marls it soon becomes abundantly clear that not a single junction will be obtained in the Southern Cliff. And the reason for this is obvious in that only the last 800 ft. of this cliff is free from falls, while even this part is tide-washed and obscured by seaweed. Several of the falls are of considerable magnitude and there is a steep turf-clad slope above them, notably the large one immediately to the east of the cables, which measures some 300 ft. across. It is only by climbing up these steep slopes that we can hope to collect *in situ* from the zone of *Holaster planus* and from the top of that of *Terebratulina gracilis*. Moreover, there is only one point at which the zone of *Micraster cor-testudinarium* can be reached, and that is from the top of one of these slopes, but the climb is too risky to be attempted lightly. At Compton Bay the "spurious Chalk Rock" formed a notable feature in the cliff, but here, at the time of our visit, we were unable to see it from the shore, and could rarely fix its position even when we had climbed to the top of the talus. The "black marl-band," as at Compton Bay, is nowhere visible as such, though we can define its position, as well as that of the "grey marl-band" and the "*Bicavea*-bed." All these features can be reached *in situ* by climbing. On the whole, the eastern cliffs of the Island compare unfavourably with the western, and had we not been able to obtain zonal junctions in the latter, we should have had here much difficulty in even guessing at the thickness of the various zones.

We now view the section from a boat, starting as before from the outcrop on the shore of the *plenus*-marls. The parallelism between this and the grand cliff between Freshwater and Sun Corner is clearly brought out. We note that the zone of *Micraster cor-anguinum* comes into the top of the cliff immediately above the outcrop on the shore of the *plenus*-marls, and from this point to the Hermit's Hole it is plainly distinguished as a thick white cap to the cliffs. If this zone measures anything like the 300 ft. which is the average of the measurements of the two sections at Freshwater Bay and Scratchell's Bay, then it is clear that not only is there no chance of getting *Uintacrinus* at the top of the Southern Cliff, but that the cliffs are not high enough to bring in the whole thickness of the zone in question.

Below this cap of white chalk we readily distinguished the nodular and reddish beds of *Micraster cor-testudinarium*, the greyer and smoother beds of *Holaster planus*, and the white and flintless chalk of the zones of *Terebratulina gracilis* and *Rhynchonella cuvieri*. As we near the Nostrils it is evident that the lower beds of *Holàster planus* fall to the shore long before we come to the end of this Southern Cliff, and that the *Micraster cor-testudinarium*-zone can alone be worked for a short distance west of the Nostrils and at the Nostrils themselves. In support of this view we may mention that we afterwards walked almost to the end of the Southern Cliff, and there obtained examples of both *Micraster cor-testudinarium* and *Micraster præcursor*. There is really no difficulty in reaching this point at low tide, for the farther one goes the better is the foothold, in that the rocks are rough with barnacles and calcareous algæ.

It is clear as we round the Shag Rock that both Nostrils are formed in the zone of *Micraster cor-testudinarium*, and that the contact with the zone of *Micraster cor-anguinum* occurs at the junction of the northern Nostril with the southern side of the projecting cliff called the White Horse. Passing to the north side of the White Horse we note that there is a little bay, in the middle of which is a recent fall, while at its southern end we see a feeble imitation of the Grand Arch at Scratchell's Bay cut, curiously enough, in the *Micraster cor-anguinum*-zone, as in the latter locality. The cliff then advances to the east and becomes higher, and we note the four lines of yellow and green nodules and the belt of flintless chalk associated with them. Then the cliff recedes again, forming a long and shallow bay which terminates in a projecting ledge running out to the east. Rounding this corner we complete our inspection of the Eastern Cliff, and enter that of Whitecliff proper. Here the cliff turns round sharply to the north-west, and we obtain a view of the junction of the Chalk with the Tertiaries. These are the main features to be noted from the sea, and these will be expanded and coupled with the necessary zoological data when we review the section *seriatim* on foot.

Zone of Rhynchonella cuvieri.

We now start once more from the point on the shore which we left to enter the boat—the outcrop of the *plenus*-marls. Passing to the east we traverse a long and splendidly-weathered section in the zone of *Rhynchonella cuvieri*, better exposed even than in Compton Bay, and, indeed, never more adequately displayed anywhere on the English Coast. Unfortunately, a fall occurs at the very spot where we should obtain a junction with the zone of *Terebratulina gracilis*, and as the fall is extensive it entirely prevents any attempt at obtaining a zonal measurement. The thickness of this zone at Compton Bay is 87 ft. 4 ins., and we have no reason to think that it is any less at the Culver.

Finely as this zone is displayed it is not a rich exposure for collecting, as we only obtained thirty-seven species. In this respect it compares unfavourably with the sections at Dover and Beer Head. The name-fossil and *Inoceramus mytiloides* are abundant, and among the usual characteristic fossils of this zone we are able to record *Discoidea dixoni*, *Cardiaster pygmæus*, *Cardiaster cretaceus*, *Hemiaster minimus*, *Cyphosoma radiatum*, *Salenia granulosa*, *Ammonites peramplus*, the usual shape-variation of *Ostrea vesicularis* and *Serpula avita*. We searched in vain for *Echinoconus subrotundus*, *Echinoconus castanea* and *Glyphocyphus radiatus*. The exposures in South Dorset were so poor that it is hardly fair to compare them with these, but we may mention that both *Echinoconus subrotundus* and *Echinoconus castanea* were obtained there and that *Glyphocyphus radiatus* was not found. As we can obtain no junction here with the *gracilis*-beds we have not attempted to give an incomplete measurement of the *Rhynchonella cuvieri*-zone.

There is no Melbourn Rock or grit-bed here. Indeed, the lower part of the zone is made up of hard, smooth, greyish chalk, with grey marl-bands every two or three feet, and *Inoceramus mytiloides* is quite rare in the lower 10 to 15 ft.

Zone of Terebratulina gracilis.

Normally, no doubt, the *gracilis*-beds are here well displayed and of considerable linear extent, but when we examined them in 1905 they were interrupted in several places by falls, so that it was impossible to even attempt any measurements. There is a small exposure of this chalk *in sitû* immediately to the east of the cables, but this is the last that we see of it, for it is then covered by the big 300 ft. fall.

A contact with the zone of *Holaster planus* can be reached by climbing up the steep talus, and such of the *gracilis*-chalk as is here exposed is in good order for collecting, though the surfaces are by no means so extensive as in Compton Bay. At the latter locality we obtained a list of sixty-three species, but here we had to be content with forty-three, and these found only by tedious climbing up the steep talus. One feature we searched for diligently, but in vain—the siliceous nodules peculiar to this zone (p. 218). Whether they were covered up by a fall, or whether they are non-existent, we know not. In any case, our faith in the persistence of lithological features in this island is of the feeblest, so it would not surprise us to find that they were actually absent. The "spurious Chalk Rock" could not be traced in the cliff save for one short exposure of a few feet, for at the level at which it should occur the chalk is much obscured by grass and talus; but that it does exist in its normal position is made clear by finding it in fallen blocks on the shore.

As at Compton Bay we note here a complete absence of *Inoceramus mytiloides* in this zone, and in place of it we find *Inoceramus lamarcki*, and more rarely *Inoceramus brongniarti*. In the upper part of this zone *Holaster planus* is rather common, and *Discoidea dixoni* is not infrequently found in the lower part. The name-fossil is only seen on air-weathered surfaces well out of reach of the waves.

Zone of Holaster planus.

If the *gracilis*-chalk be badly exposed, what shall we say ot the zone under discussion? In 1905 the junction with the zone of *Terebratulina gracilis* was buried, and the only exposure of *Holaster planus*-chalk was immediately to the east of the last big fall, and some 100 yards east of the earth-cables. We find at this spot the lowest beds of the zone, for the lowest flint-line and the "*Bicavea*-bed" are seen with the "grey marl-band" below them. Neither the "black marl-band" nor the "spurious Chalk Rock" are exposed. By climbing up the turf-clad slopes we can at several spots reach the contact of this zone with the *gracilis*-beds, and the "*Bicavea*-bed" can often be worked *in sitû*, while at one place we managed to get well up into the upper part of the zone; but nowhere could we reach a really accessible junction with the chalk of *Micraster cor-testudinarium*. The colour of the *Holaster planus*-bed is not so grey as in Dorset, and it is here certainly less nodular than the chalk of the overlaying zone; while we should also say in addition that it is less nodular than usual.

One of the chief points of lithological interest lies in the fact that the flints of the lowest flint course are often imperfectly silicified. Though this is by no means universally the case, it is sufficiently often so to be notable. There is no Chalk Rock here in the true lithological sense, and it is equally absent zoologically, tor even the ever-present *Pleurotomaria perspectiva* and *Turbo gemmatus* were for once missing, both here and at Compton Bay. We found the latter, however, in the base of the zone of *Micraster cor-testudinarium* at Watcombe Bay.

The blocks from this zone on the falls are equally numerous and well weathered, so that those who do not possess a zoological conscience to trouble them about zonal differentiation will find a rich harvest here. The richness is, however, more in the direction of number than variety. The few additions which we made to our list from fallen blocks were taken with great care, and nothing was entered unless the indication as to zone was placed beyond doubt by definite zoological evidence. We obtained a list of sixty-six species as against sixty-nine at Compton Bay. The name-fossil, *Micraster cor-bovis*, *Micraster leskei*, *Micraster præcursor*, *Echinocorys scutatus* var. *gibbus*, and *Pentacrinus agassizi* are fairly abundant; while the customary brachiopods, *Terebratula carnea*, *Terebratula semiglobosa*, *Rhynchonella cuvieri*, and *Rhynchonella reedensis* are well represented. Our only rarity consisted of *Pecten pexatus*, which we also found at Compton Bay.

Zone of Micraster cor-testudinarium.

As we have previously indicated, this zone cannot be worked *in sitû*, even on the grass slopes, and is only accessible on the shore-line at a point very near the eastern extremity of the Southern Cliff. The surface at the last locality is very poor and has a worm-eaten appearance, and is only useful in defining the position of the zone. We noted that the most easterly exposure of *Holaster planus*-chalk was situated 100 yards east of the earth-cables; then follows a small fall of large sea-weed covered blocks, and finally the sheer surface of *Micraster cor-testudinarium*-chalk, which extends to the extreme end of the section, opposite the Shag Rock.

The junction with the *Holaster planus*-zone is quite inaccessible and occurs in the sheer surface of the Southern Cliff towards its eastern extremity, and we searched in vain for the two beds of marl, 1 ft. 6 ins. apart, which mark the zonal junction so clearly in the bays of Watcombe and Freshwater.

When we visited the Nostrils we were favoured with a 26 ft. tide and a calm day, and had no difficulty in making a lengthy examination of this section on foot from Whitecliff Bay. By climbing up the ledge on the southern side of the seaward Nostril we collected some excellent examples of *Micraster cor-testudinarium* with "strongly sub-divided" ambulacra. It is clear that on this ledge we are well within the zone under discussion and not near its lower boundary.. In the roof of the southern Nostril we found a band of *Membranipora* about a foot thick. We had previously noted it on the falls, referring it to its proper horizon by means of associated Micrasters, but were very pleased to be able now to localise it so exactly. The southern Nostril is entirely in this zone, and the junction with the beds of *Micraster cor-anguinum* may be placed at the point where the out-jutting cliff called the White Horse joins the surface in which the northern Nostril is cut.

There are here none of the lithological features on which we rely at Watcombe. There is no marl-band and no pair of tabular flint bands 1 ft. apart, followed by a conspicuous belt of flintless chalk 1 ft. 3 ins. in thickness. Their absence is not a source of surprise. It is difficult to find an accurate junction here because Micrasters are rare. At Watcombe Bay we had abundant evidence of this nature, and it will be remembered that there we placed the junction in such a way that some 10 ft. of nodular chalk was included in the zone of *Micraster cor-anguinum*. If we do the same here we may take, as at Scratchell's Bay, a strong tabular flint band as our boundary line. The two Micrasters which we found in the lowest bed of nodular chalk—a bed crowded with fragments of *Inoceramus lamarcki*—had no base, and were so eroded by long exposure as to be almost indeterminable. In favour of taking the strong tabular flint band as the upper boundary of this zone, we have the fact that in the white and smooth chalk but a few feet above it we found *Epiaster gibbus*, and it is very unusual to see this urchin below the level of the *Micraster cor-anguinum*-zone.

We do not pretend to have made a list from this section, and anyone who visits the Nostrils will appreciate the reason for our reticence. The discovery of *Micraster cor-testudinarium* is sufficient evidence for us in such a section, and we are abundantly satisfied to have obtained data of so convincing a nature. The thickness of the zone is difficult to estimate, for the reason that the junction with the *Holaster planus*-zone, being in the sheer surface of the Southern Cliff, is inaccessible.

Zone of Micraster cor-anguinum.

Here again we have no chance of obtaining any definite measurement, by reason of the fact that a fresh fall has occurred in the little bay on the north side of the White Horse. The little bay is indicated on the 6-inch map by the space between the words "Whitecliff Ledge" and "White Horse." This fall had caused the chalk on either side of it to be so obscured by dust that the section in the area is quite unworkable. Our list is of necessity a meagre one, and we can only record twenty-six species. Among them we may mention the name-fossil, the typical shape-variation of *Echinocorys* belonging to the zone, *Epiaster gibbus*, the long columnar of *Bourgueticrinus*,* and sheets of *Inoceramus cuvieri*.

We obtained a measurement of 310 ft. at Scratchell's Bay, 278 ft. at Freshwater Bay, which we may roughly average at 300 ft., and we should say that there is quite that amount exposed at the Culver on the reefs.

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* "White Chalk of the English Coast. Part I," *Proc. Geol. Assoc.*, xvi (6), 1900 Pl. viii, Fig. 9.

Zone of Marsupites testudinarius.

(1) Uintacrinus-band.

This sub-zone is fairly well exposed and free from seaweed, the name-fossil is reasonably abundant and easy to see, so that it is difficult to understand why this should be the first record of its existence in this section. We got a moderately close contact with the *Marsupites*-band above, and traced it in the lower direction until we met with the area rendered dusty and unworkable by the fall already mentioned. The measurement which we give is 53 ft., as against 34 ft. 6 ins. at Scratchell's Bay. Our list is naturally but a poor one, numbering twenty-nine species in all, but included in it we record the characteristic pyramidal shape-variation of *Echinocorys*, the barrel-shaped columnar of *Bourgueticrinus*, *Terebratulina rowei*, and *Caryophyllia cylindracea*. It only remains to say that the flint courses are abundant.

Mr. Jukes-Browne (*op. cit.* vol. iii, p. 92) mentions the scarcity of flints as being characteristic of the *Marsupites*-zone. As *Uintacrinus* has until now been undiscovered, it is obvious that he there refers to the *Marsupites*-band only; but we shall show that this statement does not hold good for this sub-zone at Downend Pit, at pit No. 40, and at the bays of Freshwater and Scratchell (pp. 224 and 230).

(2) The Marsupites-band.

So far as we know, this is also the first record for this crinoid at Culver Cliff, for Mr. W. Hill does not mention it, and Mr. Griffith informs us that he and Mr. Brydone failed to find it when they examined this section. Indeed, anyone might readily be excused for overlooking it, for the lower part of the area in which it is contained is much obscured by seaweed, and our few plates were collected in the upper portion of the sub-zone alone.

The thickness obtained for the *Marsupites*-band, so far as it goes, is reasonably accurate, but the upper and lower boundaries are confessedly nebulous, in that the seaweed prevents accurate observations being made. We cannot, however, be far out with the latter, as we found a body-plate of *Uintacrinus* on a flint not far from the lowest *Marsupites* plate, and we take that as the base line. We found *Marsupites* plates on the lower side of the lowest nodule-bed, and *Actinocamax granulatus* 4 ft. above it, so that the contact with the *quadratus*-chalk is quite a close one; for we know that both in Dorset and this island the belemnite in question occurs only in the extreme base of the zone of *Actinocamax quadratus*.

We now enter that interesting area described by Mr. Whitaker in 1865, and quoted by Mr. Jukes-Browne on p. 93 of the Geological Survey Memoir on the Cretaceous Rocks, vol. iii, "Here, in the midst of the chalk, with layers of flint at every 3 or 4 feet, is a space some 40 or 50 ft. thick, with only one thin seam of tabular flint, but with four lines of green-coated nodules like those of the Chalk Rock, but perhaps of a deeper colour." This area is so remarkable that we propose to give detailed measurements of it, and to show that the lowest nodule-bed is in the *Marsupites*-band, and that the rest of the area belongs to the base of the zone of *Actinocamax quadratus.* Mr. Jukes-Browne (*op. cit.* vol. iii, p. 322), refers to these nodules as being in the upper part of the zone of *Micraster cor-anguinum*; but in a footnote on the same page he says that they are most probably in that of *Marsupites.*

It will be remembered that at Ballard Head (Part II, Dorset, p. 35), we found two yellow nodular bands. Fossils are so rare in that crushed and altered chalk that it is quite impossible to fix the exact position of these bands, but it is probable that they are much higher up in the *quadratus*-chalk than those at the Culver.

DETAILS OF THE FLINTLESS AREA AND THE NODULE BEDS.

		Ft.	In.
(4th.)	Nodule-bed	1	6
	Thin marl-seam to nodule-bed	5	0
	Nodule-bed to thin marl-seam	5	6
(3rd.)	Nodule-bed	1	0
	Thin marl-seam to nodule-bed	1	0
	Thin marl-seam to thin marl-seam	1	6
	Thin marl-seam to thin marl-seam	2	0
	Tabular flint band to thin marl-seam	3	3
	Tabular flint band to tabular flint band	7	0
	Nodule-bed to tabular flint band	4	0
(2nd.)	Nodule-bed	3	0
	Hardened chalk	2	6
(1st.)	Lowest nodule-bed	1	0
	Total	38	3

Both below the lowest nodule-bed and above the highest nodule-bed there is about 10 ft. of flintless chalk, while outside this area, both in its upper and lower limits, the chalk is seamed with frequent courses of flint.

To return to the *Marsupites*-band. We found Marsupite plates on the lower side of the lowest nodule-bed, and we place our junction with the *quadratus*-chalk midway between the lowest nodule-bed and the one succeeding it. In the second nodule-bed we had the rare good fortune to discover an example of *Actinocamax granulatus*—the third only which we have met with in nine weeks' work in the Island.

The *Marsupites*-band is, therefore, a flinty chalk, save in its upper limit, and it has in it (at the Culver only), the lowest nodule-bed. We bring out these facts in detail, as Mr. Jukes-Browne has alluded to it as a chalk characterised by the scarcity of flints.

We were quite satisfied to find a list of only fifteen species, and we offer no excuse for the fact that the name-fossil was the only one of any zonal value, for our two examples of *Echinocorys* were too broken to determine their shape-variation.

As for the measurement, we give it for what it is worth, seeing that the lower limit is obscured by seaweed. It works out at 42 ft., as against 89 ft. at Freshwater and 34½ ft. at Scratchell's Bay. We have already explained that we regard the last measurement as the more accurate, so that if we give a thickness for the whole zone, we obtain the following results:—Culver Cliff, 95 ft.; Scratchell's Bay, 81 ft. 6 in.; Freshwater Bay, 116 ft. 10 in.—an average of 97 ft. for the zone. We distrust the Freshwater measurement so much, for reasons already given, that we prefer to average the first two localities, which yields a total of 88 ft.

Zone of Actinocamax quadratus.

We have shown that the second nodule-bed contained *Actinocamax granulatus*, and we now note that immediately above it we found *Cardiaster pillula*. The highest nodule-bed, or rather series of nodule-beds, runs out as a projecting ledge from the cliff, and this is the most striking of the series by reason of the intensity of the green colouration. Masses of iron-pyrites are found in the nodules, and the Geological Survey records *Cardiaster pillula*, *Serpula plexus*, and *Rhynchonella plicatilis* for this bed. We also found *Cardiaster pillula* in this highest nodule-bed, and so did Mr. Griffith and Mr. Brydone. An account of Mr. William Hill's examination of these curious nodules is seen on p. 78 of the Geological Survey Memoir on the Isle of Wight.

From the highest nodule-bed to the north-east point of the Eastern Cliff the state of the chalk is deplorable, for, as at Ballard Head, the water oozes from the cliff and the surface is covered with red *Protococcus* slime. Toward the north-east point, where a ledge runs out due east, there are several providential little wave-scoured exposures at the foot of the cliff. As we have settled the base-line of the zone, these surfaces at its upper limit are most useful, for we are able to record *Actinocamax quadratus*, *Cardiaster pillula*, and several of the typical shape-variations ot *Echinocorys scutatus*.

We adopt the ledge, which runs out due east, as the position for the approximate junction with the *Belemnitella mucronata*-zone, as we have no data for a closer relationship than this.

Immediately we round the corner and face the Whitecliff section we find a small fall rich in a pure *mucronata* fauna, and we can see the spot whence the fallen blocks came. South of this is a small area of chalk in which we could find no fossil whatsoever. In any case, the junction which we give is probably within 10 or 15 ft. of the actual thing, and that is sufficiently close in such a surface as this.

To have found the three guide-fossils to this zone in this inhospitable section is in the last degree satisfactory, as hitherto the evidence of the *quadratus*-chalk in an extended surface is of the most indefinite nature. Dr. Barrois merely states (*op. cit.*, p. 28) that the Craie à Bélemnitelles is covered by the Tertiaries at Whitecliff, and we have no evidence in the memoir on the Isle of Wight that Mr. Strahan had examined the section from the Nostrils to Whitecliff. Mr. Jukes-Browne (*op. cit.*, vol. iii, p. 93) states that Mr. Griffith and Mr. Brydone "have found *Act. quadratus* with *Offaster pillula* in the northern part of the Culver Cliff." We wrote to Mr. Griffith on the subject, as evidence as to the exact localisation of these fossils would be of high value. In a reply dated April 26th, 1905, Mr. Griffith says: "I have a note that *Cardiaster pillula* occurs here with bands of green nodules which frequently enclose pyrites. When we examined the Culver Cliff section we knew nothing about *Actinocamax granulatus*, and our belemnite may have been of that species. Unfortunately I do not know what became of it. Probably it was only a fragment, and not thought worth preserving. We did not fix the limits of the zone, and therefore I cannot say anything as to the position of the belemnite within the zone." We discuss this matter in detail, as it would appear that Mr. Jukes-Browne's assumption that the *quadratus*-chalk exists at this position is based on the association of *Cardiaster pillula* with an undetermined belemnite—an association, moreover, which is not founded on any measurement of the zone. This belemnite may have come from anywhere in the 438 ft. of chalk above the lowest nodule bed. That *Cardiaster pillula* is not a certain guide to this zone in the Island we know to our cost, for Mr. W. Hill records it (*op. cit.*, vol. iii, p. 92) for the *Marsupites*-band at Downend Pit, Arreton, and we shall show that it is by no means an uncommon fossil from base to top of the *mucronata*-zone. We have never found more than solitary examples even in the *quadratus*-chalk in this island.

To define the position of the scanty guide-fossils in this section we would summarise as follows: *Cardiaster pillula* was found between the first and second nodule-bed (in ascending order), between the second and third nodule-bed, in the fourth nodule-bed, and the highest record which we have of it was 30 ft. from the assumed junction with the *mucronata*-zone. *Actinocamax* *granulatus* was found in the second nodule-bed, and *Actinocamax quadratus* 50 ft. below the junction with the *mucronata*-zone. Another belemnite of this group, too damaged for determination, was found on a fallen block, and therefore we do not use this as evidence. *Echinocorys scutatus*, of the characteristic shape-variation of this zone, was found only above the nodule-beds. The examples found below were too broken to give any indication of horizon. In all, we collected five well-shaped examples, the highest of which was found only a few feet below the assumed junction with the zone above.

Obviously, our list in this chalk will be but small, and we have to be content with 30 species. Among these, in addition to the guide-fossils already mentioned, we record the characteristic columnars of *Bourgueticrinus*, *Rhynchonella reedensis*, *Rhynchonella plicatilis*, and a large example of *Cœlosmilia laxa* from the highest nodule bed.

Taking the base of the zone at a point midway between the first and second nodule-beds, and the top at the ledge which runs out due east at the junction of the Eastern Cliff and the White Cliff, we obtain a thickness of 400 ft. It will be remembered that we record a measurement of 343 ft. in Scratchell's Bay (p. 231), and when writing on that section we remarked that we had expected to find a greater thickness for the zone. Here we have one more in harmony with our ideas.

Zone of Belemnitella mucronata.

We now enter upon the Whitecliff section proper. Immediately north of the southern corner of the bay we find a small fall entirely in *mucronata*-chalk. From this point to the junction with the Tertiaries, the shore is covered with fallen blocks from the same zone, and this is all the evidence that we can have in the way of collecting, for the cliff above the talus is grey with age and quite useless for this purpose. We only obtained 30 species from Whitecliff, including the name-fossil, and among them we mention an abundance of the *Echinoconus*-like shape-variation of *Echinocorys*, and two of the large dome-shaped forms, *Salenia geometrica*, *Cidaris serrata*, *Cidaris subvesiculosa*, *Aptychus portlocki*, *Serpula turbinella*, *Serpula canteriata*, *Porina filiformis*, and other characteristic bryozoa.

If we examine the reefs at low water, we see that their northern edge stands high above the sand, and is abruptly truncated. This is evidently the eroded surface which joined the Tertiaries before Whitecliff Bay was carved out of the softer Eocene rocks; for if we look shoreward along the outer edge of the reef, the eye is carried straight to the Tertiary junction in the cliff. Clearly, then, our best chance to obtain a measurement of the *mucronata*-

chalk will be to take a line across the reefs to the ledge which we have fixed as the junction of this zone with that of *Actinocamax quadratus*. This gives it a measurement, corrected for dip, of 150 ft. At the western end of the island Mr. Westlake obtained a measurement of 475 ft., and a glance at our map will show how extensive and how uneven has been the pre-Tertiary erosion of this zone all along the northern side of the Chalk Ridge. There is nothing, therefore, to occasion surprise that this eastern measurement falls so far short of that recorded at the western end of the Island.

General Description of the Chalk Ridge.

As we have before indicated in the introduction to this paper the chalk dips at a very high angle in the eastern and western limbs of the Chalk Ridge, so that from the Needles to Mottistone Down on the one hand, and from the Culver to Carisbrooke on the other, when the chalk is nearly vertical, the ridge often measures barely a quarter of a mile in thickness.

The Central Mass measures four miles in length and three in breadth, and the widening out of the Ridge at this point is due to the fact that, in addition to the bend in the strata, the lower beds of the chalk are dipping at much lower angles than in the eastern and western limbs. It will be noticed, moreover, that the inclination of the beds throughout the whole of the Chalk Ridge invariably increases in direct proportion as we ascend the zones, so that the higher beds, at the junction with the Tertiaries, are often nearly vertical, even in the Central Mass.

The Pits of the Chalk Ridge.

We have examined 200 quarries in all, and have visited every pit, working or disused, marked on the 6-inch map, as well as a few not so indicated. Of these, 108 are quarries or road-sections which give some surface, however small and badly exposed, and of this total we have failed to arrive at a definite conclusion, based on purely zoological evidence, in five only. These are the pits numbered 31, 45, 64, 90 and 96, and they nearly all offered surfaces so small and ill-exposed that it is little wonder that they yielded a negative result. The remainder were grassed over, and the large number of disused quarries, not a few with ruined kilns, are eloquent of an industry abandoned and of altered methods of agriculture. Even in the eastern and western limbs of the ridge, either right on the junction with the heavy Tertiary clays on the north, or on the light loams of the Greensand on the south, we would sometimes pass six or seven large abandoned quarries in succession. It is not that the quarries are inaccessible or rendered useless by heavy and distant haulage, for they are right on the spot where they are needed—the pure chalk to break up the heavy Tertiary clays, and the more clayey beds of the Grey Chalk to stiffen the light loams of the Greensand. Immense quantities of chalk have been quarried for agricultural purposes in the past, and one can only draw the conclusion that the farmers consider that their lands have been sufficiently limed, or that they prefer the use of modern artificial manures.

The same thing occurs in Lincolnshire where we have been recently working, for the edges of the wolds are dotted over with disused quarries, and every sheet of the 6-inch map shows numbers of shallow excavations, often in the middle of each field, where the chalk has been quarried on the spot, and the depression then ploughed over when sufficient material had been extracted. We are told by Mr. C. S. Carter that in this county, around the Louth area, extensive marling was done forty years ago, and that since then the farmers have not thought it necessary to renew the process.

Very few of the higher levels of the Downs in this island are cultivated, as the natural turf is used for sheep grazing, but occasionally they are laid down in grass for cattle, and it is then that we sometimes get a small pit used for the purpose of putting lime on the grass.

It must be understood that the state of the pits herein mentioned refers to their condition between the autumn of 1904 and the spring of 1906. We mention this because quarries which were once known to be rich in fossils are now grassed over, and discarded pits are occasionally reopened and fresh exposures afforded. When we find an exposure which is not mentioned on the 6-inch map (revised in 1896) we record the fact.

It may be said at once that the inland exposures are singularly barren and uninteresting, and we imagine that few collectors will think it worth their while to examine them. We know that all chalk pits, even in soft and horizontal chalk, yield a comparatively poor list of fossils, owing to the indifferent weathering of the surface, and that it is only by the assistance of the quarrymen that we can hope to get a useful series of specimens. In the whole island we only remember five quarries (Nos. 20, 37, 51, 77 and 104), which have a well-weathered surface, and only seven which were continuously worked (Nos. 27, 38, 49, 50, 51, 104 and 105), while in only two of them (Nos. 49 and 51) do the workmen think it worth while to preserve the fossils which they find. Curiously enough, the four quarries above mentioned are all cut in the same horizon, namely, the upper beds of the *gracilis*-chalk and the lower ones of *Holaster planus*, save No. 104, which exhibits the zone of *Rhynchonella cuvieri*. The hard and nodular nature of the chalk of this level probably accounts for this.

A reference to the maps will show how few pits there are on the crests or higher levels of the Downs, the bulk of them being hewn in the northern and southern flanks, where they are readily accessible for marling and for mending farm roads. This at once accounts for the great preponderance of the pits in the zones of *Rhynchonella cuvieri* and *Belemnitella mucronata*, and the small number referred to the zones of *Micraster cor-testudinarium*, *Micraster cor-anguinum* and *Marsupites testudinarius*.

With the exceptions already mentioned, the surface of the indurated chalk breaks up into platy masses and becomes grey and lichen-covered, instead of weathering with a clean surface; still by dint of diligent search, and by breaking up blocks with the hammer, we can generally get some zonal evidence even in these unpromising exposures. Our time has been too limited to enable us to do more than merely zone the pits, and it must be really a good surface which tempts us to make a long list of fossils.

Each pit which we discuss is numbered and marked with a corresponding number on the map. As in the paper on the Flamborough area, we place the contour-line, when it is given, by the side of the number of pit, and the letters indicating the zone beneath them, together with the sheet on our maps on which the individual pits will be found. It will be noticed that the pits do not run in consecutive numbers, but that they are taken more for geographical convenience and the ease with which they could be reached from any given point at which we were working.

The most difficult sections to zone are those in the beds of *Actinocamax quadratus* and *Micraster cor-anguinum*. The latter is always a colourless zone and the former is here equally uninteresting. In the case of the *Micraster cor-anguinum* beds we have only the name-fossil, the zonal shape-variation of *Echinocorys*, and possibly *Echinoconus vulgaris* to guide us. In the latter zone we have found one fossil, and that, curiously enough, one of great vertical range and frequent occurrence, of service in the field, and that is *Inoceramus cuvieri*. The pits are often quarried along the bedding planes, and in this zone we find great sheets of this lamellibranch coating the bedding-planes. We regard this as a distinctly useful local observation. If there be one fossil which we do not expect to find in quarries in the *quadratus*-chalk, it is the name fossil. On the coast it is rare enough, but inland it is a veritable museum curiosity. Unfortunately, *Cardiaster pillula* is not rigidly confined to its zone in the Island, so we have to fall back on the zonal shape-variation of *Echinocorys scutatus*, and this rarely fails us.

Throughout the whole of the northern surface of the Downs, most of the pits at the junction with the Tertiaries are naturally in the zone of *Belemnitella mucronata*. Here again the name-fossil, as in the Chalk Ridge in Dorset, is strangely rare, and many exposures in these beds have to be zoned without its aid.

With *Magas pumilus* very inconstant in its occurrence, and *Crania costata* and *Kingena lima* notably rare, we were again forced to adopt *Echinocorys* as our only reliable guide. Fortunately, it is generally abundant, and the small zonal shape-variation, resembling *Echinoconus conicus* in outline, rarely fails us, and we are quite content to accept it as a safe index to the zone.

Another zone which is somewhat difficult to determine is that of *Terebratulina gracilis.* When a surface is well weathered there is nothing easier to find than the name-fossil; but in chalk such as this the task is indeed difficult. However, as the only other flintless chalk is that of *Rhynchonella cuvieri*, and as *Inoceramus mytiloides* is readily detected in quarries, there is not much difficulty, by a process of diagnosis by exclusion, in arriving at a satisfactory result.

Marsupites and *Uintacrinus* are also by no means easy to see in this weather-stained chalk and require diligent search. The only zones which are really easy to determine are those of *Holaster planus*, *Micraster cor-testudinarium*, *Rhynchonella cuvieri* and *Belemnitella mucronata*—the two former chiefly on account of the facility offered by *Micraster* for rapid and certain definition; the third from the abundance of *Inoceramus mytiloides* and the ease with which it shells-out in quarries; and the fourth by reason of the almost constant occurrence of the small conical shape-variation of *Echinocorys.* However, at the risk of reiteration, we would say of the last that without this urchin it would often be impossible to separate the zones of *Belemnitella mucronata* and *Actinocamax quadratus.*

Abbreviations of Zonal Titles used in the text and maps.

B. m. = *Belemnitella mucronata.*
A. q. = *Actinocamax quadratus.*
M. and U. = The sub-zones of *Marsupites* and *Uintacrinus* of the *Marsupites*-zone.
C.-a. = *Micraster cor-anguinum.*
C.-t. = *Micraster cor-testudinarium.*
H. p. = *Holaster planus.*
T. g. = *Terebratulina gracilis.*
R. c. = *Rhynchonella cuvieri.*
A. p. = *Actinocamax plenus.*
H. s. = *Holaster subglobosus.*
C. M. = Chalk Marl.

The Western Chalk Ridge—The Needles to Shalcombe.

Sheets of 6-inch Ordnance Survey { 93 S.W. / 93 S.E. / 94 S.W. } Plate A. / Plate B. } of our map.

There are two places in the Island which can be used as convenient centres for working both the inland and coast exposures, and one for the Central Mass alone. They are, respectively, Freshwater Gate, Sandown, and Carisbrooke. From the first we can work on foot the western coast and the western limb of the Chalk Ridge as far as Shalcombe; from the second we can examine the eastern cliffs and the eastern limb of the Chalk Ridge as far as Shide; whilst from the last we can explore the whole of the Central Mass. In the case of the two latter divisions the railway can be used to save time. Therefore, instead of taking the pits in a continuous line across the island, we shall break the Downs up into sections, which can be conveniently worked from the three given points, each in the course of a single day.

West High Down and East High Down.

We have pointed out that there are no quarries on the south side of High Down, and that those mentioned by Mr. Jukes-Browne (*op. cit.*, vol. iii, p. 91) are not pits, but little adventitious exposures along the edge of the cliff.

Mr. Charles Griffith tells us that two examples of *Magas pumilus* were found in a pit opposite the old Needles Hotel, and also in another pit a little to the westward. Both these quarries are now grassed-over, and we gladly record them so as to preserve information which might otherwise be lost.

Nearly all the pits between Alum Bay and Freshwater are cut in the zone of *Belemnitella mucronata*, but one of them, namely, No. 10, showed in addition a surface of *quadratus*-chalk at the back of the quarry, and another, No. 11, was almost certainly wholly in *quadratus*-chalk.

We can give no contour-lines at the eastern and western limits of the Chalk Ridge as, for military reasons, none are printed on the 6-in. maps.

Pl. A. No. 7. [B. m.] A poor exposure, south of Alum Bay house, yielding *Belemnitella mucronata* and *Pecten cretosus*. This pit must be close to the junction with the *quadratus*-zone.

Pl. A. No. 8. [B. m.] A pit of good size, south of Nodewell. We here found *Belemnitella mucronata*, several of the small pyramidal shape-variation of *Echinocorys*, *Inoceramus* of a form unknown to us, but fully characteristic of the zone, both here and at Salisbury, and the large *Cœlosmilia laxa*. This quarry appears to be wholly in this zone.

Pl. A. No. 9. [B. m.] A small pit with very poor exposure, south of the Briary, and wholly in *mucronata*-chalk, chiefly remarkable as being one of the few exposures which yielded *Magas pumilus*. We also collected *Belemnitella mucronata*, the *Inoceramus* characteristic of the zone, *Terebratula carnea*, and *Pecten cretosus*. The shells are reddish in colour, as is often the case in this zone.

Pl. A. No. 10. [B. m.: A. q.] A large but ill-exposed pit, yielding *Belemnitella mucronata* at the northern end, *Pecten quinquecostatus* and *Ostrea vesicularis*. The back of the pit is very barren, and gave us only two examples of *Echinocorys* of the shape-variation indicative of the *quadratus*-zone. Moreover, the shells of the back of the pit were white, while those from the front were tinged with red—a useful distinction between these zones in the field. We consider that the zonal junction passes through the back of this pit.

Pl. A. No. 11. [A. q.] A pit of medium size, with poor surface, south of Farringford House. The shells are of a white colour. With the exception of two examples of *Echinocorys* of *quadratus* type, we found only *Spondylus latus* and *Ostrea vesicularis*. We believe that this section is entirely in the *quadratus*-zone, and, therefore, that the zone of *Belemnitella mucronata* has been completely denuded at this point—a point, be it noted, but two miles from Alum Bay.

Afton Down.

Pl. A. No. 1. [B. m.] There are here two pits adjoining one another and belonging to the Waterworks, and in the southern one the engineer's house is situated. We deal with this first. The section is of high interest in that it is the only one with which we are acquainted where an example of *Actinocamax quadratus* has been found at a higher level than the lowest examples of *Belemnitella mucronata*, both the belemnites being found *in sitû*. Mr. Jukes-Browne (*op. cit.* p. 93) mentions this pit, on the evidence obtained from Mr. Griffith and Mr. Brydone, but includes it under the heading of *Actinocamax quadratus* alone, whereas the whole of the northern pit (No. 2), and almost certainly the whole of the southern pit (No. 1) are cut in *mucronata*-chalk. On writing to Mr. Griffith and Mr. Brydone we have ascertained that they found a single example of *Actinocamax quadratus* and many of *Belemnitella mucronata* in the southern pit (No. 1), but that they have no recollection of the relative position of the belemnites. Our own data are as follow. In the autumn of 1904 we visited this pit accompanied by Mr. Ernest Westlake, when we found the chalk very badly exposed, especially on the southern side. Mr. Westlake found an example of *Actinocamax quadratus* a little south of the middle of the pit. We searched diligently in the southern half of the pit and the only fossils which we could find were a completely crushed example of *Echinocorys* and *Rhynchonella limbata*. All that we can say of the former is that it was too large to be an example of the small pyramidal shape-variation characteristic of the highest zone; and as for the brachiopod, that it is common in both zones. In the northern half of the quarry we collected several examples of *Belemnitella mucronata*, *Magas pumilus*, two examples of the small pyramidal *Echinocorys*, *Terebratula carnea*, *Rhynchonella plicatilis*, and *Porina filiformis*. On this evidence we placed the junction-line between the *quadratus* and *mucronata*-zones at the middle of the southern pit (No 1).

In the spring of 1906 we again visited this section, as we felt that the evidence obtained before was not conclusive. We found that the quarry had been worked in the interval, and that the southern wall was not only more accessible, but that it had been cut farther back to the south. In the southern wall we found two examples of *Belemnitella mucronata*, and south of the middle of the pit an imperfect *Echinocorys* of great size and with very thick test, together with a very large ossicle of *Pycnaster angustatus*.

It would seem, therefore, that we here have an instance of *Actinocamax quadratus* mingling with a basal *mucronata* fauna. That these two belemnites may be closely associated we know from our experience in Arish Mell (Part 2, Dorset, p. 27) where we found *in sitû* an example of *Actinocamax quadratus* a few feet below one of *Belemnitella mucronata*, with *Cardiaster pillula* between them.

We have no choice but to place the whole of this southern pit (No. 1) in the *mucronata*-zone, and it is reasonable to suppose that there may be even a small thickness of *mucronata*-chalk south of the southern wall. It will be interesting to watch the result of further excavations on the seaward side of this quarry, for in course of time we may be able to obtain a more definite knowledge of the junction between these two zones.

The section is also of interest from the fact that we can take a measurement from its southern wall to the point on the cliff where we obtain a junction between the zones of *Actinocamax quadratus* and *Marsupites testudinarius*, thereby acquiring an idea of the thickness of the *quadratus*-chalk at this point of the coast. The situation of the pits is marked on Pl. XXI, and the subject further discussed from the point of view of measurement on p. 287.

Pl. A. Pit 2. [B. m.] The pumping-house stands in this pit, and the exposure is very poor. The Engineer tells us that many belemnites were found when they were digging the shaft. In addition to the belemnite we collected several examples of *Magas pumilus*. The junction with the Tertiaries is seen in the northern side of the pit.

Pl. B. No. 3. [A. q.] There are no openings on the southern side of Afton Down, so we take the northern side, and 600 yards east of the Waterworks pits we find a small quarry with a good exposure. This section left us in no doubt as to the horizon, for we found there six examples of *Echinocorys* of the shape-variation characteristic of the *quadratus*-zone, *Cardiaster pillula*, and one example of *Actinocamax quadratus*. In addition we collected the characteristic columnar of *Bourgueticrinus*, *Pecten quinquecostatus* and *Ostrea vesicularis*.

The whole of the *mucronata*-chalk has been denuded here, and the position of this section gives us a useful line for the upper limit of the *quadratus*-zone in connection with the southern side of Pit No. 1. We have also a valuable indication of the lower limit of this zone in the position of the Reservoir on the Golf Links, for at the time of our visit in 1904, the chalk from the excavation was sufficiently recent still to have a good surface for examination (Pl. XXI). Amongst other fossils we collected here the shape-variation of *Echinocorys* characteristic of this zone and *Cardiaster pillula*.

Pl. B. No. 4. [A. q.] A disused quarry with a poor surface at the top and a steep talus of chalk, black with age. Among a list of ten species we note *Cardiaster pillula*, *Crania egnabergensis* and *Serpula turbinella*. There can be little doubt that this deep working falls well within the limits of the *quadratus*-chalk.

Pl. B. No. 6. [B. m.] This is a fair-sized pit with good surface, south of Newbarn, and clearly in the *mucronata*-zone. The back of the pit is very near the junction with the *quadratus*-zone, but it yielded a pure *mucronata* fauna, including eight examples of *Belemnitella mucronata*, three of the small pyramidal *Echinocorys*, *Pecten campaniensis*, *Spondylus spinosus*, and *Terebratulina striata*.

Shalcombe Down.

Pl. B. No. 14. [B. m.: A. q.] This is the great quarry south-west of the pond in the fork of the road at Shalcombe. There is a ruined kiln here and the upper level of the pit is no longer worked, but quarrying is still carried on in the southern and south-western corners. The southern face left us in no doubt as to the age of the chalk in that situation, for from a list of eighteen species we quote the *quadratus* shape-variation of *Echinocorys*, two examples of *Cardiaster pillula*, *Crania egnabergensis*, *Rhynchonella reedensis*, *Rhynchonella plicatilis*, *Septifer lineatus*, and *Cœlosmilia laxa*. We did not find *Actinocamax quadratus*. Some 40 ft. of this chalk is exposed, and the shells contained therein are of a white colour. About 15 ft. above the belt of chalk containing the last fossils belonging to the *quadratus*-zone we found *Belemnitella mucronata* and the small pyramidal shape-variation of *Echinocorys*. Dr. Barrois records *Magas pumilus* for this quarry, but though we visited the pit twice we were unsuccessful in our search. It probably occurred in the northern end of the section which is now obliterated.

Dr. Barrois (*op. cit.* p. 27), Mr. Jukes-Browne (*op. cit.* vol. iii, p. 93), and Mr. Strahan (*op. cit.* p. 93) mention this quarry, but none of them appear to have noticed the presence of *quadratus*-chalk. The two latter merely quote the former, but Mr. Strahan in addition propounds the novel idea that "in the upper part of the lower zone (that of *B. quadrata*), *Magas pumilus* is abundant." We can only say that we have yet to see it in that position, and we cannot help thinking that the statement is due to a mistranslation of Dr. Barrois' text.

Pl. B. No. 13. [H.p:T.g:R.c.] We now follow the road in a southernly direction and arrive at the fine quarry south-east of Five Barrows, where we find a good exposure in the zones of *Rhynchonella cuvieri*, *Terebratulina gracilis* and *Holaster planus* in their ascending order as we pass from the southern to the northern end of the pit. We here see the "spurious Chalk Rock," followed at the usual distance by the "black marl-band" and the "grey marl-band." Between the latter and the first course of flints we find the "*Bicavea*-bed," though the bryozoon was not abundant. We obtained a characteristic list of fossils from each zone, and even without the salient lithological features just mentioned we could readily have zoned the pit from the fossils alone. This quarry is mentioned by Mr. Strahan (*op. cit.* p. 83) and by Mr. Jukes-Browne (*op. cit.* vol. iii, p. 90). The former gives details of measurement, but no zoological data.

A brief search rewarded us by finding the curious siliceous nodules mentioned in the Compton Bay section of this paper (p. 218).

Pl. B. No. 12. [R. c.] Following the foot of the Down to the west we come to an exposure of considerable extent but with a poor surface for collecting. We here found *Rhynchonella cuvieri* and an abundance of *Inoceramus mytiloides*, so we have no hesitation in referring the pit to the zone of *Rhynchonella cuvieri*. We found no zoological evidence of a contact with the *gracilis*-beds.

The southern sides of Wellow and Tapnell Downs contain no quarries, and we see no more openings until we reach the southern foot of Compton Down, north of Compton Chine, where we find a small exposure in the zone of *Holaster subglobosus*, and another a little farther west, on the north side of the Military Road, also in the same zone. The northern end of this pit shows a patch of chalk belonging to the zone of *Rhynchonella cuvieri*.

The Shalcombe sections admirably illustrate the structure of the Chalk Ridge, taking us from the zone of *Rhynchonella cuvieri* on the south through *Terebratulina gracilis* and *Holaster planus* to

Actinocamax quadratus and *Belemnitella mucronata* on the north. All that is wanted is a quarry intermediate between Nos. 13 and 14 to complete the zonal picture. This brings to a close our examination of the quarries in the western end of the Chalk Ridge in the autumn of 1904.

THE EASTERN CHALK RIDGE; CULVER CLIFF TO ARRETON DOWN.

Plate F. Plate E. Plate D.	of our Map.	6 inch Ordnance Maps.	96 S.E. 96 S.W. 96 N.W. 95 N.E. 95 N.W.

Bembridge Down.

In the spring of 1905 we visited the eastern end of the island, taking Sandown as a convenient centre, and we now give a list of exposures on either side of the Chalk Ridge extending from Bembridge Down to Arreton Down, leaving the Central Mass to be dealt with in the autumn of the same year.

Pl. F. No. 16. [R. c.] A poor exposure in the zone of *Rhynchonella cuvieri* with the name-fossil and *Inoceramus mytiloides* both in evidence.

Following the line of the foot of the Down in a north-westerly direction we reach a pit the east side of the road leading to Yarbridge.

Pl. F. No. 39. [base C. a.] This is but a small and poor exposure. It is useful, however, as being in one of the rarer intermediate zones, situated as it is in the middle of the ridge. We only found ten species here, but among them was the base of *Micraster præcursor* of the form found at the base of the zone of *Micraster cor-anguinum*, together with *Cyphosoma corollare* and a perfect test of *Cidaris hirudo* with some spines attached. The Micraster is one the passage-forms in which the merely granulated condition of the periplastronal area, characteristic of the zone of *Micraster cor-testudinarium*, begins to take on a mammilated appearance as it ranges up into the base of the zone immediately above. It is for this reason that we place this little pit in the base of the zone of *Micraster cor-anguinum*. Dr. Barrois (*op. cit.* p. 24) refers this section to the zone of *Micraster cor-testudinarium*, and Mr. Strahan takes the same view (*op. cit.* p. 92).

Pl. F. No. 40. [A. q. : M.: U.] On the western side of the road, hidden by a tall hedge, we find another exposure, also in the middle of the Down, which promised to be of interest if only from its position in the ridge. It is a pit of moderate size, no longer worked, and a shed stands in it. The surface is fairly weathered, and it is easy of access as a path runs round it on the top of the talus.

The north-western corner of the pit consists merely of a grass slope with little patches of chalk emerging here and there. There are very few flints here, thus reminding one of the flintless area of chalk in the Southern Cliff of the Culver at the junction of the zone of *Marsupites testudinarius* and *Actinocamax quadratus*, where the remarkable nodular bands exist. We found, however, only one nodule-bed with green nodules in it, and below it we collected the gibbous form of *Echinocorys scutatus* and one example of *Actinocamax granulatus*. Passing thence towards the centre we find a series of plates of *Marsupites* extending over a face of chalk some 60 ft. in thickness; while, beyond this point, at the south-eastern end of the section, we obtained brachials of *Uintacrinus*, *Micraster cor-anguinum* and *Echinoconus vulgaris*. The surface is so overgrown on the northern side of the pit that we consider ourselves fortunate to have found one nodule-bed and some zonal fossils. It may be mentioned that flint courses are abundant both in the band of *Marsupites* and of *Uintacrinus*, as at the Culver. The whole quarry only yielded us a list of ten species, so it will be gathered that fossils are not abundant. This very interesting section seems to have escaped the notice of previous writers.

We now pass to the northern side of Bembridge Down where we have but one pit to record.

Pl. F. No. 15. [B. m.] Some 300 yards south of Longlands Farm is an insignificant exposure. We record from it three examples of the *Echinoconus*-shaped *Echinocorys*, *Rhynchonella reedensis*, and *Serpula turbinella*. There is no doubt therefore that the pit is in the zone of *Belemnitella mucronata*. Such exposure as there is will be found in the western end of the pit, for the eastern side is filled in with chalk tipped from the excavation for Bembridge Fort on the summit of the Down. In it we found several plates of *Marsupites*. We have alluded on p. 236 to the fact that the direction of the *Marsupites*-zone can be traced along the summit of the Down from the Marconigraph Station, through Bembridge Fort, to the centre of Pit No. 40. The Fort may not be built entirely on this zone, but part of its foundation must certainly rest on this chalk.

THE SOUTH SIDE OF THE DOWNS OF BRADING, ASHEY, MERSLEY AND ARRETON.

Plate F.	of our Map.	Sheets of 6-inch Ordnance Survey.	96 S.W.
Plate E.			96 N.W.
Plate D.			95 N.E.

This seems the natural division to make, as after we reach the great pit at Downend, Arreton, there are no exposures until we come to Shide.

Brading Down.

Pl. F. No. 38.
[R.c.: A.p.: H.s.: C.M.]

Here we have a large and well-worked quarry at the foot of the Down, north of Morton Manor. We enter the pit through a short lane cut in the Chalk Marl, and the southern wall of the pit and part of the eastern and western ends are formed by the zone of *Holaster subglobosus*, while the *Rhynchonella cuvieri*-zone alone is seen in the northern wall. The position of the *Actinocamax plenus* marls can be plainly seen, especially at the eastern ends. The men do not burn the "slipper" and are well acquainted with the belemnite found therein. This gives yet another record of *Actinocamax plenus* in an area which was not supposed to yield it. This pit is mentioned by Mr. Strahan (*op. cit.* p. 88) and by Mr. Jukes-Browne (*op. cit.* vol. ii, p. 411), both of whom give measurements.

Pl. F. No. 37.
[H.p.: T.g.: R.c.: H.s.]

A large abandoned quarry chiefly remarkable for the fact that it affords an extensively weathered surface in the upper part of the zone of *Terebratulina gracilis* and in the base of that of *Holaster planus*. It is noteworthy that almost all the well-weathered surfaces in the island are found at this particular horizon, the solitary exception being a pit on the south side of Mount Joy in the zone of *Rhynchonella cuvieri*. (Pl. XXII.)

There is a footpath which passes through its south-western extremity, and on its southern side we see a bank exposure in the zone of *Holaster subglobosus*, and on its northern side one in that of *Rhynchonella cuvieri*. As we near the main face, the zone of *Terebratulina gracilis* crops out from the grass, and the chalk of the same zone forms the base of the main section. The higher beds come in as we pass from the western to the eastern end of the section. The main face gives an admirable sequence in the upper part of the *gracilis*-chalk and the lower part of the *Holaster planus*-zone, the flinty chalk forming the highest part of it. A brief search gave us a list of forty-one species. From the top of the *gracilis*-beds we collected an abundance of the name-fossil and examples of *Micraster cor-bovis*, *Holaster planus*, and *Lima hoperi*; while in the zone above *Micraster præcursor* and *Holaster planus* were found. The "*Bicavea*-bed" is well displayed above the "grey marl-band, being," therefore, in its proper place in the top of the flintless and at the base of the flinty chalk.

In the middle of the main section is a broad shoulder of chalk which projects considerably from the main flat face. This is obviously well down in the *gracilis*-chalk, for half-way up it we see the nodule-bed of the "spurious Chalk Rock." Passing to the west, where the projecting shoulder fades into the flat surface of the cliff, we find the "black marl-band." This is very obscure where the surface is old, and it has to be cut to bring out the black colour. A notable feature in this section is the white colour of the lowest line of flints, for they look as white as the pure siliceous nodules in the *gracilis*-beds at Compton Bay. They are here inaccessible, but we found some similar flints in a fallen block at the Culver, and they were evidently from the lowest flint line, as there was an abundance of *Bicavea* associated with them. These white flints have hardly any flint recognisable as such in them, and they form an admirable link between the ordinary flints and the pure siliceous nodules described by Dr. Prior in his report (p. 289).

The measurements in this pit are given by Mr. Strahan (*op. cit.* p. 88), and by Mr. Jukes-Browne in the Cretaceous Memoir, vol. ii, p. 411. The apportionment of the beds is given correctly by the latter, the measurements given by both authors being identical.

Pl. F. No. 36. [C. a.] On the top of the Down, and facing due east, is a large quarry which is now only worked at its western end, the rest of the surface being grey with age and singularly barren of fossils. We found two damaged examples of *Micraster cor-anguinum*, two characteristic heads of *Bourgueticrinus*, *Kingena lima* and a profusion of *Inoceramus cuvieri*. The workmen quarry the chalk along the bedding-planes, and these are simply sheeted with masses of the *Inoceramus* in question. This condition is locally very significant of the zone of *Micraster cor-anguinum*.

This is presumably the pit mentioned by Dr. Barrois (*op. cit.* p. 24) who places it in the zone of *Micraster cor-testudinarium*, and by Mr. Strahan (*op. cit.* p. 92) who does the same. Mr. Jukes-Browne (*op. cit.* vol. iii, p. 92) follows Mr. Griffith and places it in the zone of *Micraster cor-anguinum*. Evidently Mr. Griffith obtained no more abundant evidence than we did, for he tells us that he referred it doubtfully to the zone in question. In any case, the position of the quarry leaves one in little doubt as to the age.

Ashey Down.

There are no more exposures on the southern side of the Downs, until we reach Ashey Down, with its well-known landmark.

Pl. E. No. 47. [C. M.] North of Kern is the fine section in the Chalk Marl known as Kern Marl Pit. As this horizon is outside the scope of our work we did not examine it in detail. Mr. Strahan (*op. cit.* p. 87) mentions it.

Pl. E. No. 29. [R.c.:A.p.:H.s.] North of Ryde Waterworks is a small and poor exposure in a disused quarry. The zone of *Rhynchonella cuvieri* is shown on the northern side, and at the eastern end the *Actinocamax plenus* marls and the zone of *Holaster subglobosus* are exposed. Passing northwards up the lane we come to a new pit with a recently worked surface.

Pl. E. No. 28. [M. c.-t] This small pit, being well up towards the centre of the Down, gives us the possibility of finding one of the zones which are so rarely seen in the Chalk Ridge, for the reason that quarries in the centre of the Down are so uncommon. The chalk is remarkably discoloured, partly by iron and partly by manganese, and fossils are very rare; but we had the good fortune to secure an excellent example of *Micraster præcursor* of the group-form associated with the zone of *Micraster cor-testudinarium*. This pit is not marked on the 1896 revision of the 6-inch map.

Mersley Down.

Pl. E. No. 27. [R. c. : A. p. : H. s.] "Mersley Limekiln" is a fine quarry and is one of the few working pits in the Island. The section is an extensive one, ranging from the Chalk-Marl to the zone of *Rhynchonella cuvieri*, and yielding the characteristic fossils of the highest zone in fair abundance. Dr. Barrois records *Inoceramus mytiloides* from "Mefsty Down" (*sc*) (*op. cit.* p. 17), which is doubtless the quarry in question, Mr. Strahan (*op. cit.* p. 87) gives measurements of it, but no fossils, and there is a mention of it by Mr. Jukes-Browne (*op. cit.* vol. ii, p. 411).

Pl. E. No. 26. [R. c. : H. s.] On the southern side of the road we find a fine section of the *Holaster subglobosus*-zone, and on the north side there is a bank exposure in the zone of *Rhynchonella cuvieri*. The zone of *Actinocamax plenus* is not seen, being probably under the road.

Pl. D. No. 25. [R. c. : A. p. : H. s.] This was once an extensive working, but is now disused, and a path runs across it. At the back of the pit the zone of *Rhynchonella cuvieri* is well exposed, and the *Actinocamax plenus* marls are clearly seen on the northern side of the path. At the bottom of the pit we find the zone of *Holaster subglobosus*. The characteristic fossils of the highest zone are fairly common. This section is mentioned by Mr. Strahan (*op. cit.* p. 87), but no fossils are given.

Pl. D. No. 24. [H. s.] Immediately to the west we find a small and very poor exposure in the zone of *Holaster subglobosus*. We found no zonal fossils, but the nature of the chalk and the position of the pit leave one in no doubt as to the horizon.

Arreton Down.

Pl. D. No. 23. [R. c.] An abandoned pit of medium size consisting mostly of talus black with age. At the extreme top there are a few surfaces of more or less white chalk, and as *Inoceramus mytiloides* and *Rhynchonella cuvieri* were obtained, there is no difficulty in assigning the quarry to the *Rhynchonella cuvieri*-zone. There is no *gracilis*-chalk at even the top of the section, though from its position on the map such would be expected to be the case.

Pl. D. No. 17a. [A. p. : H. s.] A small pit also not on the revised 6-inch map of 1896. It shews the *Actinocamax plenus* marls and the zone of *Holaster subglobosus*.

Pl. D. No. 17. [R. c.] This is merely a chalk bank which has recently been cut back, and such surface as there is may be considered good. We found several examples of *Inoceramus mytiloides*, and have no hesitation in placing the section in the *Rhynchonella cuvieri*-zone. This exposure also does not appear in the 1896 revision of the 6-inch map.

Pl. D. No. 22. [R. c.] We have here another recently cut chalk bank, which of course does not appear on the 6-inch map. It contained masses of iron pyrites. We refer it to the extreme top of the zone of *Rhynchonella cuvieri*.

Pl. D. No. 18. [T. g.] A small exposure, also not on the 1896 revised 6-inch map, with a poor surface. The pit lies north of Arreton Church and a footpath leads straight to it from the village. We found *Terebratulina gracilis* and small rod-like coral *Onchotrochus serpentinus*, which we have generally found in the *Terebratulina gracilis*-zone.

Pl. D. No. 19. [H. p. : T. g.] Yet another small exposure not marked on the revised map of 1896. We fancy, however, from correspondence with Mr. Griffith, that this section must have been in existence for a good many years, and that it is the one which originally contained a shed. The shed no longer exists, and the bank has recently been cut back. The section is chiefly of interest from the fact that the "black band" is seen in the floor of the pit, and that the "spurious Chalk Rock" is found in the south-eastern corner, with the "grey marl-band" at the top of the pit with a few feet of flintless chalk above it. We have here, then, the two highest beds of the *gracilis*-chalk and a thin capping of the *Holaster planus*-zone, the latter yielding us no fossils. The *gracilis*-beds afforded a list of seventeen species, including *Terebratulina gracilis*, *Terebratula semiglobosa*, *Rhynchonella reedensis*, *Cidaris serrifera*, *Pentacrinus* and *Serpula ilium*. The most interesting record, however, is an example of *Bicavea rotaformis* between the "black" and "grey marl-bands." This must be one of the ancestors of the race, for it is many feet lower in position than usual.

Crossing the road which intersects the Down at right-angles, we reach one of the fairest spots in an island where the abandoned quarry, clothed in luxuriant vegetation, reaches a degree of beauty which it is difficult to exaggerate.

Pl. D. No. 20.
[H. p.: T. g.]

This is the famous little disused pit which for so many years has yielded *Bicavea rotaformis* in such abundance and perfection in preservation, and is one of the few well-weathered inland exposures in the Isle of Wight. It is mentioned by Mr. Strahan (*op. cit.* p. 87) who says that Mr. Whitaker (in 1865) found the Chalk Rock at the bottom of the section. The surface is becoming much overgrown with vegetation, and at the time of our visit both the "black-band" and the "spurious Chalk Rock" were hidden by the talus. The physical features in pits vary with time, and this is a very good instance in point. The "grey marl-band," however, was clearly shown, and as there are several feet of chalk exposed below it, there is no doubt that the extreme top of the *gracilis*-chalk is still uncovered.

As on the coast, *Bicavea rotaformis* is found in the extreme base of the flinty chalk as well as in the top of the flintless series. Neither Mr. Strahan nor Mr. Jukes-Browne mention the occurrence of *Bicavea*, which is strange, for the surface is literally rough with the remains of this beautiful and distinctive bryozoon, examples of which have for many years been preserved in the Museum of Practical Geology. The north-eastern corner of the pit curves back a little, bringing in the flinty beds entirely. We found no *Micraster* or *Echinocorys* in the flinty beds, but we collected in all thirty species here, including *Holaster planus*, *Cidaris serrifera*, *Pentacrinus*, *Terebratulina gracilis*, *Terebratula semiglobosa*, *Terebratula carnea*, *Inoceramus brongniarti* and *Serpula ilium*. At the present time the zone of *Holaster planus* is alone capable of being worked.

Pl. D. No. 21.
[A. q.: M.: U.: C. a.]

We now come to the most famous of all quarries in the eastern and western limbs of the Chalk Ridge, the great Downend Pit, north of Arreton. It occupies the unusual position of the summit of the Down, and is cut through the zones of *Micraster cor-anguinum*, *Marsupites testudinarius* and *Actinocamax quadratus*. We made a careful examination of the north-western corner of the pit but could find no trace of a *mucronata* fauna. Mr. C. Griffith and Mr. R. M. Brydone, and subsequently Mr. W. Hill, were the first to discover *Marsupites* plates here. We may say at once that this quarry is singularly disappointing so far as fossils are concerned. At the time of our visit in the spring of 1905 the quarrymen were working the top of the *Marsupites*-band and the base of the *Actinocamax quadratus*-zone. The remaining surfaces were very poor and the chalk grey with long exposure. Beginning at the south-western corner, where the chalk is grey and fragmentary, we find no zonal fossils whatever, though it is obvious that we must here be in the zone of *Micraster cor-anguinum*. In the southern part of the eastern wall we found body-plates and brachials of *Uintacrinus*, and these were followed, as we passed northward, by a fair number of plates of *Marsupites*. We found *Ostrea wegmanniana* associated with *Uintacrinus* and several of the typical pyramidal shape-variations of *Echinocorys scutatus* with *Marsupites*. The *quadratus*-chalk yielded us no belemnite, and Mr. Griffith, Mr. Brydone and Mr. Hill were equally unfortunate in this respect, though the latter records *Actinocamax granulatus* in the top beds of the *Marsupites*-chalk. If Mr. Hill's localisation of this belemnite be correct, we have here an occurrence unique both in the Isle of Wight and in the corresponding chalk in Dorset, for in both localities we have only found it in the base of the *Actinocamax quadratus*-zone. *Cardiaster pillula* was represented by one very large example found in the northern wall of the pit by us ten years ago, well up in the *quadratus*-chalk, and Mr. Hill also secured one example, while Mr. Griffith and Mr. Brydone failed to find it. Mr. Hill's example was, curiously enough, obtained well down in the *Marsupites*-band (Jukes-Browne, *op. cit.* vol. iii, p. 92), and we have only twice found this urchin at this low horizon, and both were solitary examples at West Bottom, near White Nothe, and at Margate. From the *quadratus*-chalk we are able to record a list of 28 species, and among them a number of the typical gibbous form of *Echinocorys scutatus*, *Crania egnabergensis*, *Pecten cretosus*, the *Cribrilina* mentioned on page 341 of our paper on Kent and Sussex, and *Serpula turbinella*.

The whole of the *Uintacrinus*-band and all but the extreme top of the *Marsupites*-band are crowded with flint courses. Then follows a comparatively flintless area of some 40 ft. with two pairs of marl-bands in it, each pair being about 1½ ft. apart. This area corresponds to the flintless belt described by Mr. Whitaker (Jukes-Browne, *op. cit.* vol. iii, p. 93) at Culver Cliff. It will be seen, therefore, that the whole evidence points to the fact that *Marsupites* occurs in flinty chalk, for it was so at the Culver, Freshwater Bay, Scratchell's Bay and pit No. 40 at Bembridge Down. We made careful search here for the four remarkable green nodule-beds which we describe at Culver Cliff (p. 245), but failed to find them either in the quarry face or in the fallen chalk below. This disappearance of so marked and unique a feature in so short a distance is not a little interesting, and affords a cogent argument for the futility of trusting to mere lithological features.

Dr. Barrois (*op. cit.* pp. 24-28) describes the zones in this quarry, but his description is not easy to follow, as on p. 27 he says that the Margate chalk (*i. e.* the zone of *Marsupites*) is found in the southern part of the quarry, and on the following page he states that the Craie á *Bélemnitelles* is in contact with the zone of *Micraster cor-anguinum*. Mr. Strahan (*op. cit.* p. 93) merely gives a transcription of Dr. Barrois.

Pl. D. No. 30. [M. c.-a.] There is another pit on sheet 95 N.E. of the 6-inch map, and this is to be seen on the road at the north-western corner of Standen Copse. It is only a small pit, with many pipes filled with ferruginous loam. There can be no hesitation in referring it to the zone of *Micraster cor-anguinum*, as we found a well-preserved example of the name-fossil characteristic of the upper part of the zone. Fossils are rare and we can only record *Crania egnabergensis*, *Terebratulina striata*, *Serpula ilium* and masses of *Inoceramus cuvieri*—the latter being in this island practically distinctive of this zone, when it occurs in profusion such as this.

THE NORTH SIDE OF THE DOWNS OF ARRETON, MERSLEY, ASHEY, NUNWELL AND BRADING.

Arreton Down.

As one would naturally expect, all the quarries on the northern margin of the Down are cut in the zones of *Belemnitella mucronata* and *Actinocamax quadratus*, and it may be said at once that they are mostly abandoned workings and singularly barren to the collector.

Pl. D. No. 31. [? A. q.] A small exposure situated to the south of the eastern end of Saltmoor Copse. It is hardly worth examining, as it consists of an ancient talus with a small and badly exposed surface at the top. Here we obtained no zonal fossils, but from the general appearance of the chalk we should be inclined to place the pit in the zone of *Actinocamax quadratus* rather than that of *Belemnitella mucronata*.

Pl. E. No. 32. [B. m.] An old grass-grown quarry south of the western end of Hoglease Copse. Only a few inches of chalk are exposed, but we found an example of *Belemnitella mucronata* in the mouth of a rabbit-hole.

Pl. E. No. 33. [A. q.] Contrary to our expectations, this section did not turn out to be in the *mucronata*-chalk. It is rather a large pit, now densely wooded, and has a cart-track leading to it from Hoglease Copse. There can be little doubt as to the age of this section, as we found six examples of the shape-variation of *Echinocorys scutatus* characteristic of the *quadratus*-zone and one of *Cardiaster pillula*. All the northern part of the quarry, now grassed over, must have been cut in *mucronata*-chalk.

Mersley Down.

Pl. E. No. 34. [B. m.] A pit of medium size, recently worked, and situated in a copse. It is south-east of Duxmore Farm. Here again the zone is obvious, for we obtained two examples of the *Echinoconus*-shaped *Echinocorys* which is found only in the zone of *Belemnitella mucronata*.

Pl. E. No. 35. [A. q.] This was once a large working, but is now only quarried in a small face at the southern end. Fossils are very scarce, for we can only record the gibbous shape-variation of *Echinocorys scutatus* characteristic of the *quadratus*-zone, typical columnars of *Bourgueticrinus*, *Rhynchonella reedensis* and *Pecten quinquecostatus*. Even were not the position of the pit suggestive of the lower zone, the evidence of a *quadratus* fauna is quite sufficient.

Ashey Down.

Pl. E. No. 46. [B. m. : A. q.] This is the big quarry lying between the race-course and Ashey sea-mark. It is now little worked, the surface is very disappointing, and fossils are rare. At the north-east corner of the quarry we found the small pyramidal shape-variation of *Echinocorys*, *Crania costata* and *Porina filiformis*, so we can at once assign this area to the *mucronata*-zone. At the mouth of the cave we obtained the gibbous shape-variation of *Echinocorys*, and by climbing up the steep talus to the back of the pit we found another example of the same form. The southern end of the pit, therefore, belongs to the *quadratus*-chalk.

Pl. E. No. 45. [A. q.] A small exposure at the Ryde Waterworks chiefly remarkable for the fact that it exhibits a little slide-plane. In the line of crush the chalk and flint are ground up to fragments, and while the flints on the south side are practically intact, those on the northern side are shattered to splinters. Fossils are rare even for the *quadratus*-chalk of the Isle of Wight, for we only collected *Rhynchonella limbata*, *Spondylus spinosus*, *Ostrea vesicularis*, *Ostrea semiplana*. Asteroid ossicles, *Serpula ampullacea*, and *Porosphæra globularis*. The shells were of the usual colour, and not red as in the *mucronata*-chalk. The zoological evidence, slight as it is, points in the direction of the *Actinocamax quadratus*-zone, for even in small sections of the *mucronata*-chalk we can generally find one of the small pyramidal forms of *Echinocorys*, even if the name-fossil be absent. There is a steep talus of chalk tipped from the excavation for the reservoir above, and this is equally barren of fossils. The position of the pit in any case leaves us in no doubt as to the zone.

Nunwell Down.

Pl. E. No. 44.
[B. m.]
South of Nunwell Rookery is a large pit, the surfaces of which are worked at various levels, but they are all uniformly poor. The extreme back of the pit gave us no zonal fossil, but the lower surfaces at the back and sides yielded several examples of the pyramidal shape-variation of *Echinocorys*, so that the pit may safely be placed in the zone of *Belemnitella mucronata*.

Pl. E. No. 43.
[B. m.]
A small pit consisting chiefly of talus, but with a few feet of recent surface at the top. We found here three examples of the small pyramidal form of *Echinocorys*, so that the bulk of the section may with certainty be assigned to the *mucronata*-chalk.

Brading.

Pl. F. No. 42.
[B. m.]
On the outskirts of Brading, north-west of The Mall, is a pit of moderate size wherein we found *Belemnitella mucronata*, the small pyramidal shape-variation of *Echinocorys*, and *Rhynchonella limbata*: so there is no doubt as to the horizon.

Pl. F. No. 48.
[H. p.: T. g.: R. c.]
This is merely a bank exposure at Brading in a road wherein the limekiln is situated. It extends from opposite a house called "The Mount" to below the limekiln, and gives a range from the upper part of the zone of *Rhynchonella cuvieri* to the lower part of the *Holaster planus*-zone, the lowest flint line in the latter bed being shown. The surface is much hidden by bushes, and no fossils could be found, while for the same reason we could not define the "spurious Chalk Rock" and the "black marl-band." By an unfortunate oversight this section has not been marked on Plate F.

Pl. F. No. 41.
[B. m.: A. q.]
The railway cutting south-west of Brading Station affords a fair section, the northern one-third of which is in *mucronata*-chalk, while the remainder belongs to the zone of *Actinocamax quadratus*. From the higher zone we obtained a list of nineteen species, and among them we note the small pyramidal form of *Echinocorys*, *Rhynchonella plicatilis*, *Rhynchonella limbata*, the large form of *Cœlosmilia laxa*, *Serpula turbinella*, *Porina filiformis* and other rather characteristic bryozoa. An interesting occurrence was that of *Cardiaster pillula*, which was in the lower part of the *mucronata*-chalk, but not at the base. A reference to the Zonal Summary (p. 311) will show that in the Isle of Wight, at any rate, the presence of this urchin does not of necessity indicate the zone of *Actinocamax quadratus*. Towards the southern end of

the section we found an example of *Actinocamax quadratus* and an aggregation of the large form of *Serpula ilium* so massed together as to look like a colony of *Serpula plexus* with very fine tubes. No other zonal fossil was found in the *quadratus*-chalk.

THE CENTRAL MASS.

We have already explained our reason for restricting the survey of the eastern and western limbs of the Chalk Ridge to Shalcombe Down and Arreton Down respectively, and we now proceed to examine the Central Mass. Clearly, the area can best be attacked from Carisbrooke, for there is no part from Pay Down on the west to Pan Down on the east, nor the Downs of Chillerton, Shorwell and Limerstone on the south, which are not within the scope of a walker of ordinary abilities. Moreover, the lengthy western portion of this area can readily be rendered easy of access by using the railway to Calbourne.

THE NORTH SIDE OF THE DOWNS OF CARISBROOKE, APES, LITTLE, WESTOVER AND PAY.

All pits in Pl. C. of our Map, except No. 72, 73 on Pl. B. (Pan Down).	Sheets of the 6-inch Ordnance Survey.	95 N.W. 94 N.E. 94 S.E. 94 S.W.

We propose to at once reduce the work before us by taking all the pits along the Chalk and Tertiary junction, passing westward from Carisbrooke by way of Apes Down House, Ashengrove and Newbarn to Calbourne, then following the road southwards, past Westover and Gottenleaze, to a pit (No. 69) on the 300 contour-line on Westover Down. Leaving the main road we then take the path up the Down, through Westover plantation, to the northern extremity of Pay Down. It is clear that all these exposures, with the exception of pit No. 69 on the 300 contour-line at Westover Down, are likely to be in the *mucronata*-chalk.

The need for giving the contour-line in the eastern and western limbs of the Chalk Ridge is small, as nearly all the pits are on the northern and southern margins of the Downs; but in the case of the Central Mass it is clearly a convenience to know them, so we propose to place them, where possible, in round brackets on the same line as the number of the pit.

Carisbrooke.

Pl. C. No. 60 (200).
[B. m.]

This pit, long since disused, and occupied by a house and shed, is mentioned by Mr. Jukes-Browne (*op. cit.* vol. iii, p. 94) as Mord (*i.e.* Mora) Cottage, as the one in which Mr. W. Hill obtained *Magas pumilus* and part of a belemnite. The flints are black or greyish-brown, with thin white cortices, and the surface of the chalk is much obscured. The only zonal fossil yielded by the wall of the pit facing south-west was one example of the small pyramidal form of *Echinocorys* and *Porina filiformis*. In the portion of the pit in which the outhouse stands we found three examples of *Echinocorys*, all crushed, but suggestive of the shape-variation characteristic of the *quadratus*-zone, and a calyx of *Bourgueticrinus* of smaller size than is usually found at the same horizon. . It is possible, therefore, that there may be here a junction of the two zones, but the *mucronata*-chalk would have to be very thin to allow for this condition.

Pl. C. No. 61 (200). [? B. m.] A new house is being built opposite Osborne View Cottage and the chalk from the foundations was lying in heaps. We found two examples of *Echinocorys scutatus*, but they were too broken for determination.

Pl. C. No. 62 (200). [B. m.] Two large heaps of chalk from the excavations for the reservoir. The chalk is grey with age and singularly poor in fossils. Three large examples of *Serpula turbinella* and *Porina filiformis* were the only fossils suggestive of a zone. Only fragments of *Echinocorys* found.

Pl. C. No. 63 (300). [B. m.] Dr. Barrois (*op. cit.* p. 27) and Mr. Jukes-Browne (*op. cit.* iii, p. 94) mention this pit, but neither of them record any fossils. The pit is a large one and is occasionally worked, the surface being fairly good. The flints are black, with thin white cortices. We obtained here one example of *Belemnitella mucronata* and five of the small pyramidal shape-variation of *Echinocorys*.

Apes Down.

Pl. C. No. 66 (250). [B. m.] A pit of moderate size, with fairly good surface, between the 200 and 300 contour-lines and immediately to the east of Apesdown House. The only zonal fossils found were two examples of *Belemnitella mucronata* and two tall dome-shaped, but laterally compressed, forms of *Echinocorys*. Flints greyish-black, with thin white cortices.

Pl. C. No. 67 (200). [B. m.] At the farm of Apesdown House is a small pit in a pig-run. Here we obtained two examples of the small pyramidal form of *Echinocorys*.

Pl. C. No. 68 (300). [B. m.] Between Apesdown House and Ashengrove is a small pit on the south side of the road. The surface is poor and the only fossil which we could find was the small pyramidal *Echinocorys*.

Pl. C. No. 100 (275). [B. m.] On the north side of the road and opposite No. 68 is a small pit with very poor exposure. Again the small pyramidal form of *Echinocorys* was our only fossil. The pit lies nearer the 300 than the 200 contour-line.

Pl. C. No. 108 (200). [B. m.] This is a venerable surface behind some cottages at Ashengrove, in which the small pyramidal shape-variation of *Echinocorys scutatus* was our only zonal fossil.

Pl. C. No. 99 (300). [A. q.] This is the only exposure, save No. 69, which is not near the Tertiary junction, for it lies a quarter-of-a-mile south of the road and to the east of High Wood. It is a large pit with a good air-weathered surface at the top. The flints are pinkish, with thick white cortices. We obtained here *Cardiaster pillula* and the shape-variation of *Echinocorys* and *Bourgueticrinus* characteristic of the zone of *Actinocamax quadratus.*

Little Down.

Pl. C. No. 107 (250). [B. m.] To the north-east of Calbourne, in the rickyard of Newbarn Farm, is a small pit with poor surface. The flints are grey, with thin white cortices. Two examples of *Belemnitella mucronata* were found.

Pl. C. No. 89 (250). [B. m.] An old pit, with hardly any surface, in the yard of Pitt's Farm, Calbourne. The flints are grey, with thin white cortices. Six examples of the small pyramidal *Echinocorys* were found. Mr. Jukes-Browne (*op. cit.* vol. iii, p. 94) says that *Belemnitella mucronata* has been obtained here.

Westover.

Pl. C. No. 69 (300). [A. q.] North of Calbourne Bottom is a small pit with a ruined kiln. It is at the west side of the road which crosses the Westover Down at right-angles. The flints are large, grey, with thick milky cortices. We here found *Cardiaster pillula* and the gibbous shape-variation of *Echinocorys* characteristic of the *quadratus*-chalk.

Pl. C. No. 70 (275). [B. m.] West of Gottenleaze Cottages is a small pit wherein the flints are grey, with thick milky cortices. It will be noticed that though No. 69 is in *quadratus*-chalk the flints of the two pits are identical, thus showing that it is useless to rely much on them for zonal determination. We collected here twelve examples of the small pyramidal form of *Echinocorys* and two of *Belemnitella mucronata.*

Pl. C. No. 71 (350). [B. m.] West of Westover plantation is a disused pit with scattered chalk on the grass from the rabbit-warren. Flints are grey, with thick milky cortices. At the mouth of a rabbit-hole we found *Belemnitella mucronata.*

Pay Down.

Pl. B. No. 72. (325). [B. m.] North of the Ancient Cemetery is a disused quarry of large size with a few small surfaces under the turf. The flints are grey, with thick milky cortices. Fossils are scarce, but we found *Belemnitella mucronata*, *Porina filograna*, *Rhynchonella plicatilis* and the large dome-shaped *Echinocorys.*

EAST SIDE OF GARSTONS AND NEWBARN DOWNS, AND SOUTH SIDE OF CHILLERTON, SHORWELL, LIMERSTONE, BRIGHSTONE, MOTTISTONE AND PAY DOWNS.

All pits on Pl. C. of our map except No. 72. Pl. B.	Sheets of the 6-inch Ordnance Survey	95 N.W. 95 N.W. 98 N.W.	97 N.E. 94 S.E. 94 S.W.

Garstons.

Pl. C. No. 59 (300). [H. s.] At Garstons Farm there is a large pit with a recently worked surface. As this section is in a zone below the range of our work we do not give a list of fossils.

Pl. C. No. 52 (300). [H. s.] A small pit in the zone of *Holaster subglobosus* chalk on Garstons Down, south-west of Newbarn. Passing up the Down from this pit is a cart-track leading to No. 53. In the bank of this track there is a continuous exposure of the base of the *Rhynchonella cuvieri*-zone, and *Inoceramus mytiloides* is found abundantly.

Pl. C. No. 53 (400). [R. c.] A small pit, nearly obliterated, in flintless chalk. *Inoceramus mytiloides* is common.

Pl. C. No. 54, 54^{a} (500). [Ang^{r}. flint gravel.] Still passing up the cart-track for another hundred feet we notice very large flints by the road-side resembling those from the *quadratus* and *mucronata*-chalk. The reason for this is clear when we arrive at the pits, for they consist entirely of milk-white flints with no admixture of chalk. The flints are of all sizes, many of them measuring one or two feet across, and the whole deposit is bound together with a mass of flint splinters. We have here the flinty residue of the whole of the flinty chalk, due entirely to subaërial denudation. The flints are sharp and angular, and no casts or adherent fossils could be found. The large area of the central mass of the Chalk Ridge, and of the southern mass, occupied by this angular flint gravel is graphically indicated on the geologically coloured 1-inch map of the Geological Survey. We describe this exposure because, knowing the thickness of the zones of *Ryhnchonella cuvieri* and *Terebratulina gracilis*, it is obvious that this gravel rests on the base of the latter zone. All these pits are similar, so this description will do for all.

Newbarn.

Pl. C. No. 58 (300). [H. s.] A small pit recently worked. The same chalk is seen in the path leading from this quarry on the eastern side of Long Copse.

Pl. C. No. 57 (300). [H. s.] A pit of medium size with a fairly clean surface. It is also in the *Holaster subglobosus*-zone and lies to the north-east of Five Barrows (tumuli).

Chillerton.

Pl. C. No. 56 (400). [H. s.] A large working pit with a ruined kiln situated on the southern edge of Chillerton Down. Marls of *Actinocamax plenus* not exposed.

Pl. C. No. 55 (500). [R. c.] A cart-track leads from No. 56 to this pit which has an exposure of flintless chalk, grey with age, at the top of the section. Fossils are difficult to find in this loose laminated chalk, but we collected five examples of *Inoceramus mytiloides*, two of *Inoceramus brongniarti*, and two spines of *Cidaris hirudo*. We refer this quarry to the top of the *Rhynchonella cuvieri*-zone. Mr. Strahan (*op. cit.*, p. 85) mentions a pit on the projecting promontory of chalk of Chillerton Down, which he says touches the Chalk Rock. Pit No. 56 is on the actual promontory, and at the time of our visit there certainly seemed to be no trace of the greenish nodule-bed. From the base of this pit the track leads up the hill, and on the bank we successively pass the chalk of *Holaster subglobosus* and *Rhynchonella cuvieri*.

Shorwell.

Pl. C. No. 81 (300). [R. c.: H. s.] On the eastern side of the road in Shorwell Shute is the very large quarry mentioned by Mr. Strahan (*op. cit.*, p. 85). The bulk of the pit is cut in the zone of *Holaster subglobosus* and it is capped by the zone of *Rhynchonella cuvieri*. On the talus we found *Inoceramus mytiloides*. The marls of *Actinocamax plenus* could not be detected.

Limerstone.

Pl. C. No. 82 (500). [C. M.] On the southern edge of Limerstone Down is a small pit with a well-exposed surface, probably in the Chalk Marl rather than in the zone of *Holaster subglobosus*. It appears to be one of those mentioned by Mr. Strahan (*op. cit.*, p. 85) and by Dr. Barrois (*op. cit.*, p. 18).

Pl. C. No. 85 (600). [H. s.] Higher up the Down, and to the west of No. 82, is another small pit which we refer to the zone of *Holaster subglobosus*.

Pl. C. No. 83 (500). [H. s.: C. M.] At the corner of the Down is a pit of medium size with a fair surface. Mr. Strahan (*op. cit.*, p. 85) suggests that the Middle Chalk (*i.e.*, the zones of *Rhynchonella cuvieri* and *Terebratulina gracilis*) are exposed in the series of pits near Coombe Tower. We see no grounds for this supposition, and Mr. Strahan gives no zoological evidence in favour of it. Possibly he refers to the group of pits farther west (No. 77).

Pl. C. No. 84 (500). [H. s.] A small pit with slight exposure at the top on the edge of the Down, north-west of No. 83.

Brighstone.

Pl. C. No. 78 (375). [R. c.: A. p.: H. s.] North of Buddlehole Spring, on the edge of the Down, is a small pit which shows the top of the *Holaster subglobosus*-zone, the *Actinocamax plenus* marls and the base of the zone of *Rhynchonella cuvieri*. We had no difficulty in finding *Inoceramus mytiloides*. Mr. Strahan (*op. cit.*, p. 84) mentions this section.

Pl. C. No. $77^{a.b.c.}$ (400). [H. p.: T. g.] On the eastern side of the road which crosses the Down at right-angles, is a fine series of three connected pits, constituting the most interesting section in this southern area. Dr. Barrois (*op. cit.*, p. 18) and Mr. Strahan (*op. cit.*, p. 84) mention these quarries.

The lowest pit (*a*) is cut in the *gracilis*-chalk, and possibly the top of the *Rhynchonella cuvieri*-zone may be hidden under the talus. At the north side of the section we find the white siliceous nodules *in situ* a few inches below the turf cap.

In the middle pit (*b*) the base of the section is in the top of the *gracilis*-chalk, but the "spurious Chalk Rock" is hidden by talus, while the "black marl-band" and the "grey marl-band" are both well displayed in their usual relative positions. The whole of the remaining surface is cut in the zone of *Holaster planus*.

In the highest pit (*c*) the same series is shown as in (*b*), only it is much better displayed, for we have a fine exposure of the "spurious Chalk Rock," the "black marl-band" and the "grey marl-band." As Dr. Barrois points out, the position of the "black marl-band" is clearly indicated, owing to the thin line of vegetation which it supports by reason of the fact that the clay retains more moisture than the chalk. We searched for the *Bicavea*-bed, but the surface in which it should occur was grey with age, and we failed to find it.

We obtained a full list of fossils characteristic of the upper part of the *gracilis*-bed and the lower part of those of *Holaster planus*, and we can recommend this as one of the few pits in the island which a collector would care to visit. In the *Holaster planus*-chalk we had the good fortune to record two rare zonal occurrences, namely, *Echinoconus conicus* and *Discoidea dixoni*—the former for the first time in our experience. The position of the salient lithological features in pit (*c*) is well brought out in Plate XXIII. The range from the zone of *Holaster subglobosus* to that of *Holaster planus* is so well shown in the sequence of pits (No. 77-78), that we spent much time in endeavouring to bring out the zonal sequence in a photograph. We found this to be quite impossible to achieve owing to the high bank on the southern side of the road. The sequence is rendered more graphic by reason of the fact that due south of No. 78, at Rock, a section of the Malm Rock of the Upper Greensand is conspicuously displayed.

Mottistone.

Pl. C. No. 76 (350).
[H. s.: C. M.]

At the eastern end of the southern edge of Mottistone Down, well to the west of the road crossing the Downs at right-angles, is a series of large workings embracing the zone of *Holaster subglobosus* and the Chalk Marl.

Pl. C. No. 74 (550).
[R. c.: A. p.: H. s.]

This is a double pit at the angle of Mottistone Down, south of the site of Harboro' (tumuli), mentioned by Mr. Strahan (*op. cit.*, p. 84). It shows a section of the top of the *Holaster subglobosus*-zone, the marls of *Actinocamax plenus*, and the base of the *Rhynchonella cuvieri*-zone. In the latter bed *Inoceramus mytiloides* is common. We entirely agree with Mr. Strahan's description of this section.

Westover.

Pl. C. No. 75 (500). [U.] So as to save the unnecessary journey to examine one pit we now climb to the top of Westover Down in the hope that the summit may yield us one of the rare middle zones. As a pit it is non-existent, but in a shallow depression was much loose chalk, grey with long exposure. By dint of handling nearly the whole of this unpromising material we had the good fortune to find *Uintacrinus*, together with the tall pyramidal shape-variation of *Echinocorys scutatus*, characteristic of the zone in question, and *Lima decussata*.

Pay Down.

Pl. B. No. 73 (300). [H. p.] On either side of the cart-track at the south-western end of Pay Down there is a small bank-exposure of the *Holaster planus*-chalk, which yielded the gibbous form of *Echinocorys*, characteristic of the zone.

Having examined the northern and southern edges of the Central Mass it will be found convenient to divide the remaining pits into three groups: those along the Shorwell Road on the eastern side of Bowcombe and Cheverton Downs, including those on the eastern and southern sides of the Roman Road on Bowcombe and Idlecombe Downs; those on the northern side of the Roman Road at Rowridge, Swaintondown Gate, Little Down, and Newbarn Down; and those in the immediate vicinity of Carisbrooke. From the point of view of conformation it might have been better to have included those north and south of the Carisbrooke area in the groups on the northern and southern edges of the Chalk Ridge, but the distance involved renders such a course inadvisable. Method and symmetry in arranging field-work is essential, but it is also necessary to bear in mind the walking capacity of the ordinary geologist; and having been over the ground we feel that this arrangement is the one which best meets both issues. We found that we could visit every pit marked in the area which we have included in the Central Mass in five days.

THE DOWNS OF BOWCOMBE, IDLECOMBE, AND CHEVERTON.

Pl. C. of our Map | Sheets of the 6-in. Ordnance Survey employed { 94 N.E. / 94 S.E.

Bowcombe.

Pl. C. No. 65 (400). [M. c.-a.] This small pit on Bowcombe Down is south-west of the Anglo-Saxon Cemetery, and was referred by Dr. Barrois (*op. cit.*, pp. 24-27) to the zone of *Micraster cor-anguinum*, as he found there the name-fossil and *Echinoconus vulgaris*. Mr. Strahan (*op. cit.*, p. 92) is content to quote Barrois. The surface is poor, and the flints are grey-black (a few pinkish), with rather thin white cortices. From our small list we quote *Micraster cor-anguinum*, five examples of *Echinoconus vulgaris*, the zonal shape-variation of *Echinocorys scutatus*, *Cyphosoma königi* and *Pecten cretosus*.

Pl. C. No. 79 (200).
[R. c.]

On the western side of the road, opposite Bowcombe Farm, is a small pit in flintless chalk, with poor surface, in a cottage garden. *Inoceramus mytiloides* is common.

Cheverton.

Pl. C. No. 80 (300).
[R. c.]

About 1½ miles farther south, on the western side of the road, is another small pit in the *Rhynchonella cuvieri*-zone in the farmyard at Cheverton.

Leaving the Shorwell Road at Rowborough Farm we take the cart-track leading almost due north to Idlecombe Down. As we ascend the hill we see evidence of what once must have been a fair section in the zones of *Rhynchonella cuvieri* and *Terebratulina gracilis* in the western bank in the lane.

At the top of the lane is a gate, and immediately beyond it, on the east side of the track, there is a small hole in the bank from which a few loads of chalk have been taken. This is on the 300 contour-line.

Pl. C. No. 88 (300).
[T. g.]

This is the little exposure in question, and in it we see a quite recognisable section of the "spurious Chalk Rock," and we can trace the same bed of yellow and green nodules in the unmetalled surface of the track a little higher up. This pit is, therefore, in the top of the *gracilis*-beds.

Still passing up the track, we find bank exposures in the zones of *Holaster planus* and *Micraster cor-testudinarium*, though we could obtain no zoological evidence of the latter.

There is a track along the foot of Idlecombe Down, leading due west to the British Village, and following the 300 contour-line. On the northern side of the path there is an exposure of a few inches of yellow nodular chalk in which we found only *Terebratula semiglobosa* and *Spondylus spinosus*. We have no hesitation in referring it, however, to the zone of *Holaster planus*.

Mr. Strahan (*op. cit.*, p. 86) says, "There are sections of Upper and Middle Chalk close together in a lane leading up the hill to the north-west from Bowcombe, but no section of the Chalk Rock." It is probable that the section was more recent and less overgrown when Mr. Strahan saw it, though we had the advantage of seeing the little pit above the gate.

Idlecombe.

Pl. C. No. 86 (500).
[M. c.-a.]

A small pit on the Idlecombe Down, on the south side of the Roman Road, with a very poor surface. The flints are milky-white, with thin white cortices. We found *Micraster cor-anguinum* and an abundance of *Inoceramus cuvieri*, so there is not much doubt about the zone.

Pl. C. No. 87 (500).
[M. c.-a.]

South of No. 86, with, if possible, an even worse exposure, is another pit in the same zone. We obtained *Echinocorys scutatus*, of the shape-variation peculiar to this zone, and there was the same abundance of *Inoceramus cuvieri*. Flints the same as in No. 86, though some of them are of a pinkish tinge.

ROWRIDGE, SWAINTONDOWN GATE, LITTLE DOWN, AND NEWBARN DOWN.

Pl. C. of our Map. | Sheet of the 6-inch Ordnance Survey 94 S.E.

Rowridge.

Pl. C. No 97 (400).
[M. c.-a.]

Crossing the Roman Road we strike northwards to Rowridge Farm, where we find a small pit with hardly any exposure. Flints are pinkish grey, with thick pink or white cortices. The only fossil found was *Inoceramus cuvieri*, and that was abundant. We have no doubt as to the horizon of this pit, even though direct zoological evidence is lacking.

Pl. C. No. 98 (400).
[M. c.-a.]

Another small pit, north-west of Rowridge Farm. The surfaces were much obscured by downwash from the soil-cap. Flints are black, a few being pinkish, with thin cortices. One example of *Micraster cor-anguinum* found, and *Inoceramus cuvieri* abundant. This pit is very near the junction with the *Uintacrinus*-band, but the crinoid was not found.

Swaintondown Gate.

Pl. C. No. 92 (550).
[U.]

Swaintondown Gate is a farm south-west of Rowridge Farm, and as it stands on the highest level which we have worked in this area of the Central Mass we were in hopes that it would give us a higher horizon. We found only a small disused pit with a few inches of chalk below the turf and loose chalk on the grass slope. The flints are black, with thin white cortices. By dint of handling the bulk of the loose chalk, we found a number of plates of *Uintacrinus* and the barrel-shaped columnar of *Bourgueticrinus*.

Pl. C. No. 93 (500). [U.] Another small disused pit, north of Swaintondown Gate, with trees growing in it, and with the same few inches of chalk below the turf and the loose fragments on the grass slopes. By breaking up the chalk we found several plates of *Uintacrinus*, and *Rhynchonella reedensis*.

Newbarn.

Pl. C. No. 91 (330). [A. q.] The next pit is a mile away to the south-west, and is south-east of Gottenleaze. It is small and with a poor surface, and fossils are very scarce. The flints are large, grey, with thin milky cortices. We found two crushed examples of *Echinocorys scutatus* and one columnar of *Bourgueticrinus* of the shape-variations suggestive of this zone.

Pl. C. No. 94 (400). [A. q.] Half a mile north-east of No. 91 is a disused pit with 1 ft. of broken chalk below the turf. Flints are black with thin white cortices. Our only fossil was *Echinocorys scutatus* of the shape-variation characteristic of the zone.

Little Down.

Pl. C. No. 90 (300). [? B. m.] A large freshly-made heap of chalk from the excavation for Calbourne Reservoir. Flints milky, with thin milky cortices. The chalk is clean and rain-washed, but singularly barren of fossils. Two fragments of *Echinocorys* were found, but nothing distinctive of a zone. There can be little doubt, however, that it lies within the *mucronata*-zone.

Pl. C. No. 96 (400). [A. q.] Due east of No. 90 is a small pit with a good surface but exhibiting a strange rarity of fossils. Flints black, with thick white cortices. The only fossil of a distinctive nature was an example of the *Cribrilina* generally associated with the *quadratus*-chalk. We incline, therefore, to this horizon, for the position on the map would seem to make the age quite clear. In our anxiety to find more definite evidence we paid two visits to this pit.

Pl. C. No. 95 (300). [B. m.] To the north-west of No. 96 is a pit of fair size with some exposure at the top of a steep talus. Flints are black with pinkish tinge and with cortices often pink and moderately thick. Fossils are very scarce. Mr. Jukes-Browne (*op. cit.*, vol. iii, p. 94) evidently refers to this pit as he localises it as south-east of Newbarn, and states that *Belemnitella mucronata* has been found there. We obtained a list of seven species on our first visit, but not one of them was of zonal value, but at a second examination we found *Magas pumilus* on a flint. The section must be very near to the junction with the zone immediately below.

THE CARISBROOKE AREA, INCLUDING MOUNT JOY AND PAN DOWN.

Pl. C. and Pl. D. of our Map.	Sheets of the 6-inch Ordnance Survey.	95 N.W. 94 N.E.

Mount Joy.

Pl.D. No. 105(175). [B. m.] A large quarry in White Pit Lane with a working kiln. Flints are greyish or black, with thin white cortices. We found here one example of *Belemnitella mucronata* and three tall, dome-shaped, and laterally compressed forms of *Echinocorys scutatus*, similar to those obtained in Pit No. 66 and at Alum Bay. Mr. Jukes-Browne (*op. cit.*, vol. iii, p. 91) mentions the fact that fossils are very scarce here, and that both Mr. Hill and Mr. Griffith, for want of zoological evidence, place the section tentatively in the zone of *Micraster cor-anguinum*. The very position of the pit would make such a horizon unlikely, and the evidence from fossils now obtained places the question of zone beyond doubt.

Pl.D. No. 104(200). [R. c.] On the south side of Mount Joy is a quarry of medium size in flintless chalk with a well-weathered surface. They burn the chalk from this pit in the kiln of No. 105. *Inoceramus mytiloides* is abundant, and we also obtained *Rhynchonella cuvieri* and *Discoidea dixoni*. Mr. Strahan mentions this pit (*op. cit.*, p. 86) but gives no fossils.

Pl.D. No. 51 (200). [H.p.: T.g.: R.c.] At the south-west end of Mount Joy, and to the east of the Castle, is one of the few good pits in the whole island, giving a range from the zone of *Rhynchonella cuvieri* to that of *Holaster planus*. It contains a working kiln, the surface is in the main excellent, and it is one of the two pits where the workmen keep fossils for sale. We obtained forty-two species here. At the time of our visit they were only working the *gracilis*-chalk. The section displaying the zone of *Rhynchonella cuvieri* is incomplete, as the *Actinocamax plenus* marls are not exposed; moreover, the surface is not of the best. Among the fossils obtained from this horizon we record *Inoceramus mytiloides*, *Rhynchonella cuvieri*, and *Ammonites peramplus*.

A freshly cut surface in the *gracilis*-chalk is not calculated to yield many fossils, but from a list of thirteen species we select *Terebratulina gracilis*, *Echinoconus subrotundus*, *Ammonites peramplus*, *Radiolites mortoni* and *Nautilus*.

We only found twenty-one species in the zone of *Holaster planus*, but among them we note *Holaster planus*, *Micraster leskei*, *Micraster cor-bovis*, the characteristic shape-variation of *Echinocorys*, *Echinoconus vulgaris*, *Cyphosoma radiatum*, *Rhynchonella cuvieri*, *Terebratulina gracilis*, *Terebratula carnea*, *Terebratula semiglobosa*, *Inoceramus brongniarti* and *Bicavea rotaformis*.

The siliceous nodules were found *in sitû* in the *gracilis*-beds and the "spurious Chalk Rock," together with the "black marl-band" and "grey marl-band," were well displayed. The "black marl-band" can here be readily traced, as in pit No. 77, right across the northern wall of this quarry by means of the line of vegetation growing on it. Mr. Strahan (*op. cit.*, p. 86) gives detailed measurements of the section, and in speaking of the obvious fault says: "The fault runs W. 15° S., very nearly along the strike of the strata which it throws down to the north, its effect being to depress out of sight an unknown thickness of the upper beds of the Middle Chalk. The Dip points a little west of north at 42°." The siliceous nodules are situated in the north-east corner of the quarry.

Pan Down.

Pl. D. No. 49 (200).
[B. m.: A. q.]

This is the great Shide quarry, the largest and most actively worked in the island. Mr. Jukes-Browne (*op cit.*, vol. iii, p. 93) records both *Belemnitella mucronata* and *Actinocamax quadratus* from this pit on the evidence of Mr. C. Griffith and Mr. R. M. Brydone, and the former belemnite is fairly abundant; but though we made diligent search for it in every accessible portion of the south side of the pit on two occasions we never had the good fortune to find the latter, nor had the workmen any at the time of our visits. The foreman is quite familiar with the two forms and says that the smaller form (*Actinocamax quadratus*) is very rare, and is only found at the southern side of the pit. The exposure on this side of the quarry is very poor, and we could obtain no evidence of a fauna indicative of the *quadratus*-zone. Whether there be here, as in pit No. 1, an intermingling of the two belemnites at the lower limit of the *mucronata*-zone, or an actual junction, with limitation of the two belemnites to their respective zones, we know not; nor have Mr. Griffith and Mr. Brydone any more conclusive evidence on this point, as their specimens of *Actinocamax quadratus* were obtained from the workmen.

We collected twenty-three species in the *mucronata*-zone, including *Belemnitella mucronata*, the small pyramidal form of *Echinocorys*, as well as the very large pointed form similar to that in the Norwich chalk, *Cardiaster pillula*, *Magas pumilus*, *Rhynchonella limbata* and *Porina filiformis*. The examples of *Magas pumilus* and *Cardiaster pillula* were found together at the highest part of the northern wall of the pit, close to the Tertiary junction. We mention this to show that the latter fossil in no way indicates the presence of *quadratus*-chalk in this island. The only time that the southern wall of the pit can be examined in comfort in when the workmen are absent, as blasting operations are constantly going on.

Pl. D. No. 50 (200). [C. M.] On the south side of the Down, and north of West Standen farm, is a large quarry with a working kiln. The workmen do not keep the fossils.

Carisbrooke.

Pl. C. 103 (100). [T. g.] Mr. Strahan (*op. cit.*, p. 86), speaking of the Middle Chalk, says, "We first see it in a cutting where three lanes meet at Clatterford. Thence it runs along the south front of the hill on which the castle stands . . . to a quarry near the Convent." At the time of our visit there was a small bank exposure with yellowish, nodular and flintless chalk, and the same was seen in the footpath leading to the castle, but the "Spurious Chalk Rock" was not seen, though we broke down the surface freely with a hammer, nor could we find any fossil. The horizon is, therefore, speculative, but we prefer to place it in the upper part of the *gracilis*-beds rather than in the extreme base of the zone of *Holaster planus*.

Pl. C. No. 102. [H. s.] South of the Lukely Brook and below the 100 contour-line is a small disused pit in flintless chalk. The chalk is covered with dust and no fossils could be found; but it breaks with a fracture resembling that of the zone of *Holaster subglobosus*, and, when placed on the tongue, has the distinctive taste of clay.

Pl. C. No. 101 (200). [M. c.-t.] On the western outskirts of Clatterford, and on the west side of the Shorwell Road, is a pit of moderate size in which is situated the garden of Bowcombe Barn Farm. As the pit has long been disused the surface is not inviting, but zonal evidence is not wanting, for *Micraster cor-testudinarium* and *Micraster præcursor* of the group-form characteristic of this zone are abundant, especially the former. The flints are solid and black, and have thin white cortices. It is curious that this pit, situated as it is on an interesting zonal level of the Down, has escaped the notice of previous writers. This is only the second exposure in the Island in which this zone is exhibited.

Pl. C. 64 (400). [A. q.] Following the Shorwell Road to the south we ascend the Down at Whiteland Homestead till we reach its crest, and there on the 400 contour-line is a small abandoned pit with a few inches of chalk below the turf and scattered chalk on the grass. The only fossils we found were *Rhynchonella plicatilis*, *Inoceramus cuvieri* and *Ostrea vesicularis*, and these only by handling all the scattered chalk and breaking up the larger pieces. From its position, however, there cannot be much doubt that the horizon which we give is correct. We place it in the base of the zone.

Pl. C. No. 106 (350). [U.] It may be said at once that this is not a pit, but the unmetalled cart-track leading down to Whiteland Homestead, with lumps of chalk exposed therein at intervals. As we descended the track we broke up the surface with our hammers in the hope of finding *Marsupites*, but without result. However, in the position in which we ought to find *Uintacrinus* that most valuable little guide-fossil was obtained. Towards the bottom of the lane we found the nodular chalk of the *Holaster planus*-zone, and lower down the *gracilis*-chalk was seen, but we could not detect the existence of the "spurious Chalk Rock." The Chalk Rock line, however, on the 1-inch map coloured geologically is drawn through here and is in the correct position. Possibly this lane gave a good section in past years.

SUMMARY OF INFORMATION CONCERNING CHALK PITS.

So many of the pits are useless to the collector that we have thought it worth while to bring into tabular form those pits which are of interest, either from the standpoint of prominent lithological features, or for the occurence of important zonal fossils. In relation to the latter, it may be said at once that none of the quarries, save Nos. 20, 27, 51 and 77, are richly fossiliferous, and that those which display the lower two-thirds of the *gracilis*-beds, and the zones *Micraster cor-testudinarium*, *Micraster cor-anguinum*, *Marsupites testudinarius* and *Actinocamax quadratus*, though the best in the island, are poor compared with the standard of other and more favoured localities on the mainland. The numbers given refer to the number of the pit quoted.

SECTIONS SHOWING THE "SPURIOUS CHALK ROCK" AND THE "BLACK MARL-BAND."—19 Arreton, 37 Brading, 13 Shalcombe, 51 Carisbrooke, 77 Mottistone, the Military Road at Freshwater, and Compton Bay and Culver Cliff on the coast.

SECTIONS SHOWING THE WHITE SILICEOUS NODULES.—The Military Road at Freshwater, 13 Shalcombe, 51 Carisbrooke, 77 Mottistone, and Compton Bay on the coast.

SECTIONS YIELDING *Cardiaster pillula.*—3 and 4 Afton, 14

Shalcombe, 69 Westover, 49 Shide, 99 Apes Down, 41 Brading Station, and Scratchell's Bay and Alum Bay on the coast.

SECTIONS YIELDING *Actinocamax quadratus.*—1 Freshwater, 3 Afton, 41 Brading Station, and at Culver Cliff and Scratchell's Bay on the coast.

SECTIONS YIELDING *Actinocamax granulatus.*—40 Bembridge, and at Culver Cliff and Scratchell's Bay on the coast.

SECTIONS YIELDING *Bicavea rotaformis.*—The Military Road at Freshwater, 13 Shalcombe, 19 and 20 Arreton, 37 Brading, 51 Carisbrooke, and at Compton Bay and Culver Cliff on the coast.

SECTIONS YIELDING *Magas pumilus.*—1 and 2 Freshwater, 49 Shide, 9 High Down, 95 Little Down, and at Alum Bay on the coast.

The list of quarries given below is on the whole the best which we can compile for the display of the various zones :—

B. m.—1 Freshwater and 49 Shide.
A. q.—14 Shalcombe.
M.—40 Bembridge and 21 Downend.
U.—40 Bembridge.
M. c.-a.—36 Brading and 65 Bowcombe.
M. c.-t.—101 Carisbrooke.
H. p.—20 Arreton, 37 Brading, 51 Mount Joy, and 77 Mottistone.
T. g.—37 Brading, 51 Mount Joy, and 77 Mottistone.
R. c.—27 Mersley and 104 Mount Joy.

Measurements.

It will facilitate reference if we bring together in tabular form the measurements which we record for the eastern and western ends of the island. Mr. Ernest Westlake took infinite pains to ensure their accuracy, and we give them, in full confidence that they will be found to be substantially correct.

The comparison between the eastern and western ends of the island would have been of greater interest had we been able in the former area to obtain zonal junctions from the zone of *Rhynchonella cuvieri* to that of *Micraster cor-anguinum.* However, by working at low tides, and by dint of wading and swimming, Mr. Westlake managed to get a combined measurement across the reefs from the top of the marls of *Actinocamax plenus* in Sandown Bay to the junction of the zone of *Micraster cor-anguinum* with the *Uintacrinus*-band in the recess on the north side of the White Horse at the Culver. The latter junction, it will be remembered, is not a definite one, as there had been a fall of chalk there before our arrival, and the cliff at that point was so obscured by dust that fossils could not be seen. In any case, the junction which we fixed, corresponding with the north side of the incipient Grand Arch before mentioned, is sufficently close to be of value in making a calculation.

Mr. Westlake fixes the thickness of the portion of the zones which we could not measure in the cliff (base of *R. cuvieri* to top of *M. cor-anguinum*) at 568 ft. This, added to the 645 ft. obtained by actual measurement of the beds above the *Micraster cor-anguinum*-zone, gives a total thickness for the eastern end of 1,213 ft. If we take the measured thickness of the beds in the western end of the island, from the top of the *Micraster cor-anguinum*-zone downwards, which comes to 572 ft. 10 ins., and add this to the sum of the higher measured beds in the eastern end, we have a total of 1,217 ft. 10 ins., as against the measurement of 1,213 ft. just given. The two totals, estimated in this way, are only five feet apart.

Comparing now the eastern and western measurements, respectively 1,213 ft. and 1,471 ft., we find a difference of 258 ft. in favour of the western end; and putting aside the variation in thickness of the respective zones, it is clear that the chief factor in the discrepancy lies in the larger thickness of the *mucronata*-chalk at the Needles—a difference of no less than 325 ft. By subtracting this 325 ft. from the western total of 1,471 ft. we reduce it to 1,146 ft.; and subtracting the last figures from the eastern total of 1,213 ft. we find that there is a balance of 67 ft. in favour of the eastern end of the island. This is as close as we could reasonably expect to get, and bears out our opinion expressed before the measurements were completed, that the eastern measurements would work out as high, if not higher, than those of the western series.

The thickness of the *mucronata*-chalk varies greatly along the northern margin of the Chalk Ridge and testifies to an amount of pre-Tertiary denudation which it would be impossible to anticipate. For instance, at pits Nos. 11 High Down, 4 and 8 Afton Down, and 23 Mersley Down the *quadratus*-chalk, to the best of our belief, has a junction with the Tertiaries; while in pits Nos. 10 High Down, 60 Carisbrooke, 19 Pan Down and 46 Ashey Down, only a comparatively thin layer of *mucronata*-chalk intervenes between the *quadratus*-chalk and the Eocene.

TABLE OF MEASUREMENTS.

Western end.					Eastern end.		
	ft.	in.	ft.	in.		ft.	ft.
Zone of *Belemnitella mucronata* .	475	0			150	645	
„ *Actinocamax quadratus* .	343	0			400		
„ *Marsupites testudinarius* .	47	0	81	6	42		
„ *Uintacrinus* . . .	34	6			53		645
„ *Micraster cor-anguinum* .	310	0	572	10		568	
„ *Micraster cor-testudinarium*	52	9					
„ *Holaster planus* . . .	59	9					
„ *Terebratulina gracilis* . .	64	9					
„ *Rhynchonella cuvieri* . .	84	7					568
Total . . .	1,471	10	Total . . .				1,213

Mr. Strahan (*op. cit.*, p. 75) gives a measurement of about 1,536 ft. for the White Chalk at the Culver, but the thickness of the chalk-with-flints, which is given as 1,350 ft., is obtained by estimation and not by direct measurement; while the flintless chalk, about 188 ft., was measured bed by bed to the base of the *Rhynchonella cuvieri*-zone.

Mr. Jukes-Browne, on the other hand (*op. cit.*, vol. iii, p. 88), bases his estimate on a section drawn through Arreton Down, and gives a total of 1,240 ft., and he considers Mr. Strahan's figures as rather too high. In this opinion we entirely concur. Mr. Jukes-Browne apportions his zonal estimate as follows. They are suppositional estimates, and not direct measurements, and are probably based on the figures given for the coast of Dorset.

	ft.
Zone of *Belemnitella mucronata*	300
„ *Actinocamax quadratus*	400
„ *Marsupites testudinarius*	150
„ *Micraster cor-anguinum*	300
„ *Micraster cor-testudinarium* and *Holaster planus*	90
Total	1,240 ft.

It will be noted that Mr. Jukes-Browne's estimates for the zones of *Micraster cor-anguinum* and *Actinocamax quadratus* are practically identical with our actual measurements, and that those for the combined zones of *Micraster cor-testudinarium* and *Holaster planus* are twenty-two and a half feet less than those which we record. On referring to the Geological Survey Memoir on the Cretaceous Rocks, vol. ii, p. 413, we find a measurement given for the zones of *Rhynchonella cuvieri* and *Terebratulina gracilis* of 151 feet at Compton Bay, and this added to the 1,240 ft. for the remaining zones gives a total of 1,391 ft., or 186 ft. in excess of our result.

A comparison of our measurements here with those of the Dorset Coast will clearly be of interest, and these we find are 73 ft. in excess of our figures in the Isle of Wight. The measurements selected from our paper on the Dorset Coast are those which we believe to be the most accurate. They are as follows:

	ft.	
Zone of *Belemnitella mucronata*	289 (250+39+x).*	
„ *Actinocamax quadratus*	350	
„ *Marsupites testudinarius*	30	111
„ *Uintacrinus*	81	
„ *Micraster cor-anguinum*	240	
„ *Micraster cor-testudinarium*	113	
„ *Holaster planus*	51	
„ *Terebratulina gracilis*	58	
„ *Rhynchonella cuvieri*	76	
Total	1,288 ft.	

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* "White Chalk of the English Coast." *Proc. Geol Assoc.*, xvi (1). p. 42, 1901.

That there is some difficulty in arriving at a definite measurement in rocks tilted at varying angles may be judged from the following totals given by recent writers on the chalk of this island.

	ft.	
Dr. Barrois	950	(290 metres).
Mr. Strahan	1,536	
Mr. Jukes-Browne	1,391	
Mr. Westlake	1,215	in this paper.

We now revert to the measurements relating to pit No. 1 at Freshwater Gate, which we touched on in the description of the pit. As the *mucronata*-chalk is there exposed, and as we get a contact between the zones of *Actinocamax quadratus* and *Marsupites* on the shore, it is clear that we have an opportunity of gauging the thickness of the *quadratus*-chalk. From the junction with the Eocene to the southern wall of pit No. 1, wherein we found two examples of *Belemnitella mucronata*, is 180 ft., but unfortunately the pit is not cut sufficiently to the south to justify us in assuming that the *mucronata*-chalk is complete in its lower direction. Granting that it be so, we have only a measurement from the southern wall of the pit to the base of the *quadratus*-zone on the shore of 314 ft. At Scratchell's Bay we obtained a thickness for this chalk of 343 ft., and at the Culver of 400 ft., so that the Freshwater measurement is conspicuously less than either, and this in face of the fact that there may still be an appreciable thickness of *mucronata*-chalk on the seaward side of the quarry. We do not seek to explain away these marked variations in thickness, but simply give the facts as they work out. The position of the pits is indicated on the map (Pl. A) and on the Key-plate to Pl. XXI.

LITHOLOGICAL SUMMARY.

Save for the indurated nature of the rock, the comminution of flints, the "spurious Chalk Rock," the nodule-beds at the top of the *Marsupites*-band and the base of the zone of *Actinocamax quadratus*, the "black marl-band" and the siliceous nodules in the *gracilis*-beds, the White Chalk of the Isle of Wight offers but little to distinguish it from that of southern England. The same indurated nature of the rock, seaming with calcite, and splintering of flint was seen in Dorset, and is due to the same cause—the compression of rock associated with the tilting of beds at high angles. Though the chalk is not so indurated as that within the area of disturbance in Dorset, we have yet to see a section in the Island where the chalk is not abnormally hard, or where fossils are capable of being cleaned, save only the actual contact with the Eocene at Alum Bay. As a rule, the hardness increases in direct proportion as we ascend the zones, for the reason that the stress on the rocks and the inclination of the beds increase in like manner.

Zone of Rhynchonella cuvieri.

A flintless chalk conforming in the main to the bed of this horizon in the south of England in that there are alternations of smooth and nodular chalk, and that the surface is rough, at varying levels, with fragments of *Inoceramus mytiloides*. In Dorset there was a band of nodular flint near the junction with the zone immediately above. There is no trace of a Melbourn Rock or Grit bed; indeed, the actual base of the zone is of a green-grey colour from admixture of marl, and has several strong dark marl-seams with reddish nodular inclusions in them, and it is not until about 8 ft. from the base that *Inoceramus mytiloides* becomes at all abundant. It is difficult to account for the frequent allusion to the Melbourn Rock in the Geology of the Isle of Wight (*Mem. Geol. Survey*), for nowhere do we see the base of the zone undercut and projecting as a prominent overhang owing to the falling away of the *plenus*-marls; nor do we ever see on the southern flank of the Downs any feature thrown up to indicate the position of this bed. At Dover the overhang of the Grit-bed is a common and notable feature.

Zone of Terebratulina gracilis.

This is again, as in Dorset, a wholly flintless chalk, and is a counterpart of the same zone in the southern counties in that the chalk, though white, is finely veined with marl, and marly partings are, as usual, a conspicuous feature. It is towards the top of this zone that Mr. Whitaker's "Chalk Rock" occurs—a notable bed of yellow or green nodules in a rugged yellow matrix. It forms a conspicuous feature in the cliffs and quarries, and is most useful as a rough guide to horizon. Still nearer the top of the zone we find the "black marl-band" which was first pointed out by Dr. Barrois, and save only for the "black band" in Yorkshire, which is the local equivalent of the *plenus*-marls, we know of no other black marl-band in the White Chalk. Curiously enough, it never shows up as black in colour on the coast, but it is invariably black inland, and can always be traced by the line of vegetation growing on it on account of the greater moisture held in the clay. The position of these two features is found in the description of this zone in Compton Bay, and is indicated on the Key-plates to Pls. XXII and XXIII.

But the chief interest in this zone lies in the distribution and transitional stages of silica. We have called this a flintless chalk, and so it is, save for two singular bands of siliceous nodules bedded in marl-seams and situated about 37½ ft. from the top of this zone. Mr. Strahan records these nodules in his Memoir, for he says (*op. cit.*, p. 77) "but below the lowest flint there occur nodules of hard siliceous chalk, having the form of flints but the texture of chalk." They are so like flints that when we first saw one we gave it a blow with the hammer, thinking that it was a white flint, and were surprised to find the hammer cut into it as if it were chalk. When we were working in pit No. 51 we asked the foreman if he had seen them before, and he replied, "Yes, I know them well. They won't burn"; and in support of his statement brought out two which had been in the kiln, with the result that they were vitrified. The curious part of the distribution of silica is that there is rather more than 40 ft. of flintless chalk intervening between the siliceous nodules and the first bed of hard flint in the zone of *Holaster planus*. But these flints, nearly always, in the Island, of the nature described, are remarkable. They ring to the hammer like an ordinary flint, but they are almost white from cortex to centre, and quite solid. Some get greyer towards the centre, and others are white throughout, save for little greyish areas irregularly distributed. Above this bed the flints gradually assume the ordinary appearance, ranging in colour from grey to black, with thick white or grey cortices, and they are solid and but little crushed. So white are the flints in the lowest flint-course in the zone of *Holaster planus* that they show up plainly in Pl. XXII of pit No. 37, where they are indicated on the Key-plate. In the island an uncrushed example of *Echinocorys* is one of the rarest occurrences. Our few comparatively perfect specimens are in-filled with flint. Though by no means conclusive proof, it is evidence which points in the direction of the assumption that the silica had in-filled the hollow tests of these urchins in the earlier stages of the history of the Chalk, either before it had been elevated, or in any case before it had the later tilting in Tertiary times. It certainly looks as if the solid flint mould had prevented that crushing and distortion, so obvious in the case of the other urchins which, by reason of the absence of the solid core of flint, were less able to offer resistance to the interstitial movements in the rock.

REPORT ON A WHITE SILICEOUS NODULE.

By GEORGE THURLAND PRIOR, M.A., D.Sc., F.G.S.

The nodule from the *gracilis*-beds, Compton Bay, submitted to me for examination by Dr. Rowe, consists of fairly pure silica with only traces of calcareous material. Very little soluble silica was extracted by prolonged digestion with a strong solution of sodium carbonate. No phosphate was detected in the brown surface matter. Under the microscope a thin slice shows with 1-inch objective and between crossed nicols only one or two indistinct calcareous remains of organisms, and here and there minute flakes of quartz. With a $\frac{1}{4}$-inch objective the section shows between crossed nicols a similar mottled chalcedonic structure to that observed in flints. Compared with a flint from the chalk of Margate the structure of the nodule only differs in being rather more obscure and in showing fewer round patches of distinctly radiating material. Throughout the slice very faint curved markings suggestive of the remains of foraminifera can be made out. [G.T.P.]

Zone of Holaster planus.

As usual, the chalk of this zone is rugged and nodular, of a somewhat grey tint, contrasting thereby with the redder tinge of the zone above; though the distinction is not so marked as in Dorset. There is no Chalk Rock in this zone in the lithological sense. The description of the flints in this zone is given in the last paragraph relating to the *gracilis*-zone. The grey tint of the zone is due to admixture with marl.

Zone of Micraster cor-testudinarium.

The chalk of this zone is of the usual rugged nature from the presence of bands of nodular chalk irregularly arranged in the smoother and softer rock. The general colour of the zone is somewhat reddish from colouration with iron-oxide. If the flints at Watcombe Bay may be taken as an index of the rest, they are black and solid, with thin white cortices. As a rule, the flints are not notably shattered in this zone, and they follow the ordinary rule of being arranged in irregular courses. Several tabular bands of flint occur at this horizon.

Zone of Micraster cor-anguinum.

Save at the base of the zone, where the chalk shows several nodular bands similar to those on the Sussex coast, the rock is smooth and massive, and the flint-lines run in regular courses. The flints are more cavernous than in the zone immediately below, and for the first time we find a definite proportion of globular flints, which frequently enclose remains of *Plinthosella*. The flints are slightly pink towards the surface and have thin cortices, but there is no invariable rule on this point. There are occasional bands of tabular flint, and a few marl-seams.

Zone of Marsupites testudinarius.

The chalk is compact and white, and the flint courses are numerous, but not so regularly arranged as in the zone below. The flints are solid and black, and as a rule have thick white cortices, but here again there are frequent local variations, as we point out in the various sections of the paper.

Zone of Actinocamax quadratus.

A white massive chalk, with minute veins of marl traversing it, and with open seams of the same material here and there. From this faint admixture with marl the chalk is not so white as the zone of *Belemnitella mucronata*. The flints at Scratchell's Bay are black and solid, and have thin white cortices, but there is no limit to their variation in other sections. Tabular bands of flints occur occasionally. It is mainly in the flintless area of this zone that the remarkable green nodule-beds of the Culver are situated, allusion to which has already been made on p. 245. They were equally well displayed in a freshly-made trench at the top of Culver Cliff; while one band only could be found at pit No. 40 on Bembridge Down, and none at Downend Pit (No. 21) or at Scratchell's Bay. As in Dorset, the flints are sometimes very large in this zone.

Zone of Belemnitella mucronata.

This is essentially a pure, white, massive chalk, with numerous irregular flint courses, some of the individual flints being of great size; but there are no pot-stones or paramoudras. There is no limit to the variety in colour of the flints: at Scratchell's Bay they vary from black to a rich umber, and the cortices are respectively either fawn-coloured or white, the cortex generally being thin, while in other sections the body of the flint is smoke-grey in tint.

ZOOLOGICAL SUMMARY.

So many workers in the field have testified to the usefulness of a fuller discussion of the zonal fossils in a summary such as this that we have no hesitation in adopting once more what has now become our usual course. Moreover, a survey of critical zonal faunas is obviously out of place in the description of the various cliff sections, if only for the reason that it would introduce a mass of detail which would obscure the simplicity of the issue before us. It must be understood that the present tabular summary applies to the faunas of the several zones in the Isle of Wight alone. Those who are interested in these matters will see, if they refer to the previous summaries in the four divisions of this work, that there are often wide divergences in the critical faunas of the counties in question. After all, however, this is only what we should expect to find, for Nature's operations in the present are only an echo of those in the past, and however great the variations in the zonal guide-fossils may appear to be, this very variation is the strongest testimony to the validity of the zonal theory; for comparatively small variations in depth of sea and in temperature and strength of currents will cause surprising alterations in a fauna in areas which are geographically as closely related as the counties of Dorset, Wiltshire, and Hampshire are to the Isle of Wight.

The longer we work in the field, and the more we extend our observations over a wider area, the greater is the vertical range obtained for guide-fossils, which were once thought to have much more restricted zonal limits. This, again, is only natural, but the fact is of importance in that it tends to bridge over apparently unintelligible gaps in the life history of certain fossils. For instance, *Kingena lima* was supposed to range from the upper part of the zone of *Micraster cor-anguinum* to that of *Belemnitella mucronata*, and yet it existed in profusion in the zone of *Holaster subglobosus*; but now we have filled in the gap and find that at the levels at which it is rarest in the Southern Counties it is commonest in Lincolnshire. So again with *Infulaster rostratus*, a rare echinid in the south of England, ranging from the zone of *Micraster cor-anguinum* to that of *Actinocamax quadratus*: but our investigations in Yorkshire not only extended its downward range by one zone but showed it to be locally at a certain horizon one of the commonest of fossils. *Cidaris pleracantha*, hitherto only known as a museum curiosity in the zone of *Holaster subglobosus*, has now been found by us in the *mucronata*-chalk, and on p. 317 we show how the gap between these two distant horizons has been still further reduced. Other less important work in the same direction is seen in the present paper in the increased range of such fossils as *Cidaris clavigera*, *Cidaris subvesiculosa*, *Cardiaster pillula*, *Echinoconus subrotundus*, *Echinoconus vulgaris*, *Hemiaster minimus*, *Cyphosoma spatuliferum*, *Ophiura*, *Nautilus* cf. *atlas*, *Aptychus portlocki*, *Rhynchonella reedensis*, *Rhynchonella limbata*, *Spondylus dutempleanus*, *Lima cretacea*, *Lima decussata*, *Pteria* (*Avicula*) *cærulescens*, *Ostrea wegmanniana*, *Radolites* cf. *mortoni*, *Plicatula barroisi*, *Pollicipes glaber*, *Onchotrochus serpentinus*, *Micrabacia coronula*, *Podoseris* sp., *Stephanophyllia bowerbanki*, *Serpula pusilla* and *Serpula cincta*. Some of these are also new records.

Zone of Rhynchonella cuvieri.

As in Dorset, there is here no true Melbourn Rock, and our summary must, therefore, be one for fossils common throughout the zone:

Rhynchonella cuvieri . . .	84 ft. 7 in.
Inoceramus mytiloides . .	
Discoidea dixoni . . .	
Hemiaster minimus . . .	
Ammonites peramplus . .	
Serpula avita	

Other characteristic fossils are: *Echinoconus subrotundus*, *Cardiaster pygmæus*, *Cardiaster cretaceus* and *Salenia granulosa*.

Save at the extreme base of the bed in the Island, *Rhynchonella cuvieri* and *Inoceramus mytiloides* are found in abundance throughout the zone, but the latter gets rarer as we near the junction with the zone immediately above. These are the only two fossils which we can always count on finding in the wretched surfaces seen in quarries in the Island. The longer we work in the field the more are we convinced that in inland sections at any rate, the lamellibranch as proposed by Dr. Barrois, is the more suitable name-fossil, both from its relative abundance, the ease with which it catches the eye, and its complete restriction to the zone under discussion.

The only other fossil which is at all abundant at this horizon in all the southern counties is *Discoidea dixoni*. It was not found in Yorkshire, but the sections there are so poor that it may be present. The disadvantage of its employment as a guide fossil is that it is not restricted to the zone in question; but after all that objection is not a very cogent one, for it would apply with equal force to *Rhynchonella cuvieri*, the actual name-fossil of the zone. The point is that it reaches its maximum development at this horizon. *Hemiaster minimus* shares with the last echinid the same reproach, and, we may add, the same extenuation, for it certainly is commoner here than at any other horizon. Hitherto we have not obtained it higher than the zone of *Micraster cor-testudinarium*, but we shall shew that we found it in the *Micraster cor-anguinum*-zone at the Culver, and recently we have been able to still further extend its range, for there is a well-preserved example in Dr. Blackmore's beautiful collection derived from the *quadratus*-chalk of Harnham, Salisbury.

Ammonites peramplus, absent in Dorset, is never a common fossil, save at Dover, but we found it in several sections of this zone in the Island, and it was, as usual, of large size. We did not see *A. cunningtoni* or *A. catinus* which we have before been able to record for this horizon. We found *Nautilus* sp. at pit No. 51 Carisbrooke, which is an occurrence of sufficient rarity to need mention.

Serpula avita is the form to which we first called attention in Part iii, Devon, p. 34, as a fossil rigidly confined to this zone. It is here found abundantly, as in all other southern sections, and is always attached to *Inoceramus mytiloides*.

In the Dorset paper we had to omit *Cardiaster pygmæus* from the summary, but here it comes in again as a somewhat rare fossil, for we found but six examples in all. *Cardiaster cretaceus* is also sparingly represented here, and it will be remembered that we obtained one example in Dorset also; whereas in S. Devon it was abundant.

Echinoconus subrotundus is worthy of a special note, though the whole island furnishes us with but a solitary example in this zone. It is a curious fact that Desor,* who figures and describes this usually rather abundant urchin, states that his single specimen, on which Agassiz founded his type, came from the Isle of Wight. Zones were unknown in those days, but it is strange that this type should have come from a locality where it is so unusually rare; and the matter is further complicated by the fact that Desor's figure is not that of the inflated form with conspicuously narrow base (well figured by Wright in Palæont. Soc.) but of the form with less inflated sides and less contraction of the base, which is characteristic of the *gracilis*-beds. We only found one example of *Echinoconus castanea* in Dorset and none here, while it is abundant in S. Devon and well represented in Kent.

Salenia granulosa, here as elsewhere, is one of the forms which has little claims to zonal distinction, as it ranges from base to top of the White Chalk. It is, however, never a common fossil, and perhaps reaches its greatest numerical development in this zone, and for that reason we mention it among the associated guide-fossils.

Among the cidarites we record here for this zone are *Cidaris hirudo*, *C. serrifera*, and *C. clavigera*. The first is always common and is the only cidarite which ranges in unbroken profusion throughout the White Chalk. *Cidaris serrifera* we have recorded before for this horizon, but it is never a common form, and here we found only three examples in all. *Cidaris clavigera*, on the other hand, has never appeared at this level in our published lists, though we have known of it for some years, for we found it at Dover, and we now quote three examples from Compton Bay.

The remaining groups in Echinoderma call for little comment. We found here *Cyphosoma radiatum* and *Pentacrinus agassizi*, but for once failed to obtain *Glyphocyphus radiatus*. The last we once thought was absolutely restricted to this zone, but we found an example in the *gracilis*-beds at Whitecliff, Seaton, and Mr. W. Johnson has since collected another high up in the same zone in the Hooken, Beer Head.

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* Desor, "Monog. des Galérites," p. 18, 1842.

Of the brachiopods we may mention that, as in Dorset, we did not find here the form which we know as *Terebratula semiglobosa* var. *albensis*, which we regard as somewhat characteristic of the zone; but we record several examples of *Terebratulina gracilis* from the lower part of the zone. Further experience shows that it always occurs sporadically at this level.

The only lamellibranchs calling for notice are *Spondylus dutempleanus* and *Teredo amphisbæna.* The former is a rare fossil in Sussex and Devon, but was not found in Dorset; while the latter is usually seen at this horizon, often with tubes measuring a foot in length. Both were found here.

Of the corals, we record for the Island the usual rare dwarfed form of *Parasmilia centralis*, and give a new record in *Onchotrochus serpentinus.* Since the Dorset paper was published, we have found a considerable number of this small rod-like coral at Dover, and we once more met with it in the Island, where it is quite rare at this level. In the *gracilis*-beds, however, we shall show that, as at Dover and Beer Head, it is by no means of rare occurrence.

Sponges, usually abundant at this horizon, are here poorly represented, though such forms as we find are characteristic. Neither *Craticularia fittoni* nor *Cephalites* were found, and *Camerospongia* was represented by a single example.

Another new record is that of *Serpula granulata*, which we have found both here and at Dover. It is rare in the *gracilis*-beds. Our only vertebrate remains consisted of a tooth of *Ptychodus mammillaris* at the Culver. Our note book shews a list of only forty-eight species for this zone.

Zone of Terebratulina gracilis.

Terebratulina gracilis *Micraster cor-bovis* *Holaster planus* *Inoceramus lamarcki* *Inoceramus brongniarti*	64 ft. 9 in.

Other characteristic fossils are: *Discoidea dixoni*, *Hemiaster minimus*, *Pentacrinus agassizi*, *Rhynchonella cuvieri*, *Onchotrochus serpentinus*, and *Craticularia fittoni.*

The name-fossil is always abundant throughout the zone, so that the interest here, as elsewhere in the southern counties, centres round Echinoderma.

Holaster planus is here abundant in the upper one-third of the zone, and diminishes in frequency as we pass towards the lower limit, conforming in this respect to the normal range in other sections. It is quite as common in the top of the *gracilis*-beds as in its own zone.

Echinoconus subrotundus. This is the form which corresponds with Desor's figure,* in that the base is not contracted and the inflation of the test but of moderate degree. Curiously enough it is here much commoner at this horizon than in its normal position in the zone below. We may mention, however, that we have a large series of this zonal variation characteristic of the *gracilis*-zone from that level at Dover, while it is rare in Dorset, Devon, and Sussex. We found eight examples in all scattered throughout the zone, one at Compton Bay being actually above the "spurious Chalk Rock." We fancy that this will turn out to be the highest known occurrence for this echinid.

We need hardly say that *Micraster cor-bovis* is the only Micraster found at this horizon. We were led to anticipate that we should not see it in this zone, for Mr. Jukes-Browne (*op. cit.*, vol. ii, p. 410) says . . . "Micrasters are so rare that it is uncertain whether any specimen or fragment of one has yet been found in what we call the Middle Chalk." There is only one good and complete section in this zone in the Island and that is at Compton Bay, but here we found eleven examples, all removed and cleaned before determination, in one day, and we also record it for pit No. 37, Brading, and at the Culver. The above statement, therefore, will require considerable modification. *Holaster placenta*, usually abundant in the upper part of the zone, was not found.

Of the other echinids we have only to note that *Discoidea dixoni* and *Hemiaster minimus*, usually well represented at this level, are rarer than usual in the Island; that *Cyphosoma radiatum* is found in its customary abundance; and that *Salenia granulosa* is wanting from our lists.

The usual cidarites are all well exemplified here, for we find *Cidaris hirudo*, *C. serrifera*, *C. clavigera*, and in addition we have to establish a new zonal record for *C. subvesiculosa*, which was represented by a single spine from Compton Bay. *Pentacrinus agassizi* was found scattered throughout the zone, becoming commoner and larger towards its upper limit.

The brachiopods call for no comment, but the lamellibranchs here furnish us with several interesting occurrences. We record one example of *Pecten pexatus*, thus corresponding with our solitary record for the same zone in the Hooken, Beer Head. Among the Inocerami we note a narrow form of *Inoceramus lamarcki*, and *Inoceramus brongniarti*; but, though we made especial search for it, we failed to see a single example of *Inoceramus mytiloides*.

Lima decussata appears for the first time in our lists in this zone, for we found here three examples. As we shall afterwards show, we also obtained it in the zone of *Holaster planus*, the *Uintacrinus*-band, and in the zone of *Belemnitella mucronata*. Our only other record is a single example from the zone of

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* *Op. cit.*, p. 18, Tab. 2, Figs. 11—14.

Micraster cor-testudinarium at Dover. Dr. Blackmore has found it in the *Uintacrinus*-band and in the zones of *Actimocamax quadratus* and *Belemnitella mucronata* of Salisbury.

Lima hoperi, of the customary small size, was found, together with *Lima cretacea*, at Compton Bay, the latter being the lowest occurrence which we have hitherto established. Up to this time we have only found it from the zone of *Holaster planus* to that of *Micraster cor-anguinum*, but Dr. Blackmore obtains it in the *Marsupites*-band and in the base of the *quadratus*-chalk in the Salisbury area. We also list one example of *Radiolites mortoni* from the Culver, which Mr. Griffith, like ourselves, has hitherto not seen above the zone of *Rhynchonella cuvieri*. We have one curious exception to make to this statement, namely, a single example from the *Uintacrinus*-band of Margate. Gasteropods are poorly represented, but we collected single specimens of *Pleurotomaria perspectiva* and *Aporrhais* from Compton Bay, both of which are very scarce fossils at Dover at the same horizon.

Another new record is that of *Nautilus* cf. *atlas* from pit No. 51, Carisbrooke. Hitherto our only other record for this cephalopod was the zone of *Micraster cor-testudinarium* at Pinhay, South Devon; but recently we have found it in the zone of *Holaster planus*, Homington Hill, Salisbury. *Ammonites peramplus* was also found at pit No. 51, and it is not an infrequent fossil at this level.

Three corals are of special interest. We have alluded to the occurrence of *Onchotrochus serpentinus* in the zone of *Rhynchonella cuvieri* in the Island and at Dover, and we have now collected in addition over a dozen examples in the *gracilis*-beds at the Culver, Compton Bay, and pit No. 18, Arreton, while we obtained one example in the zone of *Holaster planus* at Culver Cliff, and several at the same horizon and in the *Micraster cor-testudinarium*-zone at Dover. This tiny tube-like coral has, therefore, a range through the four lower zones, being very small in the two lowest and increasing in size above that level. Its small size is in marked contrast to the more massive form, often several inches in length, which we find in the zone of *Micraster cor-anguinum* in Thanet and elsewhere. Mr. Lang is of opinion that this is not a new species of *Onchotrochus*, but simply a zonal variation of *Onchotrochus serpentinus*. The dwarfed size, here as elsewhere, of *Parasmilia centralis* in the two lower zones affords another illustration of the constancy of form and size which even the less important fossils assume at definite horizons, thereby affording an almost limitless scope for the precise study of zonal variations. Of equal importance are two examples of *Stephanophyllia bowerbanki* which we have found at Compton Bay in the upper part of this zone, both above and below the "spurious Chalk Rock." Previously we had found two examples in the lower part of the

Rhynchonella cuvieri-zone at Dover, and so far as we know, these are quite new to English workers in the field. We searched in vain for a coral belonging to the genus *Podoseris*, two examples of which we found in the *Rhynchonella cuvieri*-zone of Dover, constituting also, as we believe, another new record for the White Chalk in England.

Yet another new record of equal interest is that of *Micrabacia coronula*, also found in the upper part of this zone at Compton Bay. It is not a little strange that this coral, which is so abundant in the zone of *Holaster subglobosus*, should be found in the upper part of the *gracilis*-beds, and that both here and at Dover it should be apparently absent in the zone of *Rhynchonella cuvieri*. The only other coral found was an example of *Axogaster cretacea*.

Cirripedes are always scarce in this zone. *Scalpellum maximum*, though rare, has been found before, as we record it for South Devon. We obtained it here also.

The sponges in this zone are usually very numerous and well preserved; but here they are comparatively rare and the iron-oxide pseudomorphs are very faint in colour. *Craticularia fittoni*, which is characteristic of this zone and of that immediately below, was found at the Culver.

The only vertebrate remains are teeth of *Lamna appendiculata* and *Oxyrrhina mantelli*. Owing to the good and complete section at Compton Bay (good, that is, for the Isle of Wight), we are able to give a list of ninety species in this zone.

Zone of Holaster planus.

	ft. in.
Holaster planus *Micraster præcursor* (of the group-form characteristic of this zone) *Micraster cor-bovis* *Micraster leskei* *Echinocorys scutatus* (a characteristic gibbous form) *Pentacrinus agassizi* *Cidaris serrifera*	59 9

Other characteristic fossils are *Holaster placenta*, *Cyphosoma radiatum*, *Rhynchonella cuvieri*, *Rhynchonella reedensis*, *Terebratulina gracilis*, *Crania egnabergensis*, *Inoceramus brongniarti*, *Plicatula barroisi*, *Bicavea rotaformis*, *Semicytis rugosa*, *Eschara acis*, *Serpula ilium*, *Ventriculites impressus* and *Ventriculites mammillaris*.

The name-fossil is abundant here throughout the zone, and *Micraster præcursor*, *Micraster leskei*, *Micraster cor-bovis*, *Hemiaster minimus* and *Cyphosoma radiatum* are found in their usual relative proportions. Concerning *Micraster præcursor* we would only remark that both in shape-variation and in the essential features of the test this urchin differs in no respects from those obtained at the same horizon in other English sections. The broad form, known on the Continent as *Micraster decipiens* is notably rare here, and the same applies to *Holaster placenta.*

We have at pit No. 77A, Mottistone Down, our second record for *Discoidea dixoni*, the first being for Dover, and both occurring in the base of the zone; but our most interesting record is for *Echinoconus vulgaris*, which hitherto we have never found below the zone of *Micraster cor-testudinarium*, where it is a rare fossil. One example was found at pit No. 51, Carisbrooke, and the other at pit No. 77A, Mottistone Down, and both unfortunately were too crushed to enable one to determine with certainty the shape-variation. We shall show later on that it has also been obtained here in the two highest zones, thus giving us a complete zonal continuity in the genus for the whole of the White Chalk—a thing never before achieved.

Another new zonal record is that for *Cyphosoma spatuliferum* which we found at pit No. 20, Arreton Down. Hitherto we have only recorded it from the zones of *Micraster cor-anguinum* and *Marsupites*, while Mr. Griffith lists it in the former zone, and Dr. Blackmore gives it a range in the Salisbury area identical with ours.

The cidarites here present no new feature, but we may mention that one example of *Cidaris perornata* was found in this zone both at Culver Cliff and Compton Bay. Dr. Blackmore finds this species only in the zone of *Micraster cor-anguinum* in the Salisbury area, and Mr. Griffith in the same zone and that of *Holaster planus* in Hampshire. This, however, is by no means the lowest occurrence, for we have recorded single examples from the zones of *Terebratulina gracilis* and *Rhynchonella cuvieri* at Dover, as well as several from the zone of *Micraster cor-testudinarium*; but it must be understood that below the zone of *Micraster cor-anguinum* it is a rare fossil (see p. 304).

Ophiura was for the first time found by us at this horizon at the Culver, and we have now collected it in every zone save that of *Micraster cor-testudinarium*. *Pentacrinus agassizi* was as usual abundant and of large size, and we had the good fortune to find for the first time one of the most elusive fossils in this zone—the head of *Bourgueticrinus*, for the Culver and Compton Bay both yielded us examples. Columnars of this crinoid are abundant and are always of small size, differing only from those in the two lower zones by being progressively larger. Reverting to the head of this crinoid, we may say that the largest example is less than half the size of an adult specimen from the zone of *Micraster cor-anguinum* and that instead of expanding in pear-shape form there is merely a uniform expansion from the proximal to the distal end. The measurements of these three examples were 7 mm. × 3 mm., 5 mm. × 3 mm., and 4 mm. × 2½ mm.

The brachiopods here offer nothing of note, save that *Rhyncho-*

nella plicatilis is small and rare, while *Terebratula carnea* and *Terebratula semiglobosa* never reach the size or abundance which we are wont to associate with this horizon. We find the usual abundance of *Terebratulina gracilis* at the base of this zone, and it extends in rapidly diminishing numbers to its upper limit.

Among lamellibranchs we mention three examples of the rather rare *Pecten pexatus* at the Culver ; *Inoceramus brongniarti*, *Inoceramus* sp. mentioned by Mr. Woods* and previously quoted in this zone, occurring here as a rare fossil only at Compton Bay; and *Lima hoperi*, as usual of rather small size, and obtained both at the Culver and pit No. 37, Brading Down. Three examples of *Lima decussata* appear in our lists for this zone, one from Culver Cliff and the others from pits No. 20, Arreton Down and No. 37, Brading Down. We also collected a single example of *Lima wintonensis* at the Culver for the determination of which we are indebted to Mr. Henry Woods, the author of the species. Another new record in our experience is a single example of *Ostrea wegmanniana* at this horizon. Dr. Blackmore finds it only in the *Marsupites*-zone at Salisbury, but we have it in our general lists from the zone of *Micraster cor-anguinum* upwards, becoming quite rare in the highest zone of all.

The absence of the customary gasteropods *Turbo* and *Pleurotomaria* at this horizon is not a little curious, as even in Dorset we found them both. In their place we found one example of *Aporrhais* at Compton Bay.

We have alluded to the beautiful little rotiform bryozoon recently described by Dr. Gregory under the name of *Bicavea rotaformis*. It is so much a feature of this bed, and occurs in such boundless profusion, that we can only wonder how it is that so many previous writers, including the authors of the Geological Survey Memoirs, have omitted to mention it. Reference to the level at which it occurs, and the sections in which it is found, will be seen on p. 284 of this paper. Not only is it abundant but on suitable air-weathered surfaces it is in a wonderful state of preservation. We have a series of examples where the parent has thrown out a stolon from which is springing a young form.

Corals are here represented by *Parasmilia centralis* and a single example of the small form of *Onchotrochus serpentinus*.

Scalpellum maximum, an example each from the Culver and Compton Bay, together with a single carina of *Pollicipes glaber*, are our only Cirripedes. We fancy that the last named forms infinitely the lowest zonal record for this rather rare fossil.

Serpulæ now begin to be common ; and we here record *Serpula ilium*, *S. plana*, *S. ampullacea*, *S. fluctuata*, *S. cincta*, *S. pentangulata*, *S. granulata*, and a form, never perfect, with a long thin smooth tube, which is not a young or uncoiled example of *S. ampullacea*, nor can it be referred to *S. gordialis*.

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* H. Woods. "The Mollusca of the Chalk Rock: Part II," *Quart. Jcurn. Geol. Soc.*, Vol. liii, 1897, p. 381, pl. xxviii, figs. 14-17.

Once again we have to note the rarity of vertebrate remains, for here we only record *Ptychodus mammillaris* and *Lamna appendiculata*. We obtained in all a list of 98 species in this zone.

Zone of Micraster cor-testudinarium.

	Ft.	In.
Micraster cor-testudinarium (of group-form characteristic of the zone)	52	9
Micraster præcursor (of group-form characteristic of the zone)		
Echinocorys scutatus (of the characteristic gibbous form)		
Cidaris serrifera		

Other characteristic fossils are: *Holaster placenta*, *Rhynchonella reedensis*, *Crania egnabergensis*, *Plicatula barroisi*, *Pavolunulites*, *Eschara acis*, *Heteropora pulchella*, *Semicytis rugosa*, *Reticulopora obliqua*, *Serpula cincta* and *Serpula ilium*.

Here, as in Dorset, the broad group-form known as *Micraster cor-testudinarium* is more numerous than the narrow group-form known as *Micraster præcursor*. Both these urchins in every way conform in shape-variation and in essential features of the test to the characters typical of this zone. The gibbous form of *Echinocorys scutatus*, so characteristic of this zone and that of *Holaster planus*, is less common than usual, but it is the only form seen; while *Holaster placenta*, usually almost as common as *Echinocorys*, is certainly rarer than we should expect. The remaining genera of Echinoderma, such as *Hemiaster minimus*, *Cyphosoma radiatum*, *Salenia granulosa*, *Cidaris hirudo*, *C. serrifera*, *C. perornata*, *C. sceptrifera* and *C. clavigera*, are all represented in their customary numerical proportions, though *C. clavigera* in no way approaches the abundant occurrence seen at Beachy Head and Seaford Head. It is in this zone, and in that of *Holaster planus*, that *Cidaris serrifera* generally attains its maximum numerical development, though it is not confined to this level, for we find it as a rare fossil in the *Rhynchonella cuvieri*-zone, and rather less rare in the *gracilis*-beds, while it is never seen above the lower half of the zone of *Micraster cor-anguinum*. We cannot record for the island, either in this zone or that of *Holaster planus*, a single example of *Cardiaster cotteauanus*.

At this horizon also we had the good fortune to find a single head of *Bourgueticrinus ellipticus* at Watcombe Bay. This example differed in no way from those mentioned on p. 299 from the zone of *Holaster planus*. The only other locality where we have collected the head of this crinoid is Dover, and there we obtained five examples, varying in size from 11-mm. by 5-mm. to 5-mm. by 4-mm. In this zone the affinity with the pear-shaped form of the shape-variation characteristic of the *Micraster cor-anguinum*-zone is much more in evidence, and it would be difficult to say in what the largest and most expanded example differs from the typical form of the zone immediately above, save only in size.

Of the brachiopods we need only say that *Crania egnabergensis* is here, as usual, rather common at this horizon, and that *Rhynchonella plicatilis* has for once no place in our list. In this zone and the one immediately below *Crania egnabergensis* is a rather common shell, ranging from the *gracilis*-chalk to the *quadratus*-chalk, though we have a record of one example in the *mucronata*-zone. It is only in the *quadratus*-chalk that it is really at all common again, and there in all English sections it seems to be of rather larger size and with costæ wider apart. *Rhynchonella limbata* would hardly be regarded as a characteristic fossil of this zone, as it is generally associated in our minds as a guide fossil to the two highest zones. It is found at Dover, and to a much less extent in Sussex, in such numbers that it is necessary to mention its absence in the Island. In this zone and in that of *Holaster planus* it is broad and flat with a wavy margin. We can now give a record for this brachiopod in every zone of the White Chalk, for during the past three years we have found it in the zones of *Rhynchonella cuvieri* and *Terebratulina gracilis* at Dover, two examples in the former and several in the latter.

Among the more interesting lamellibranchs we would cite *Plicatula barroisi* and *Inoceramus lamarcki.* The range of the former has gradually been extended until we have obtained it in every zone in the White Chalk, but the only two zones where it is really abundant are those of *Holaster planus* and *Micraster cor-testudinarium.* The broad form of *Inoceramus lamarcki* would at this horizon, and to a less extent in the zone immeately below, appear to dispute pride of place with *Inoceramus cuvieri.* Both shells were found in the Island.

Here, as in Sussex, *Pavolunulites*, apparently of an undetermined form, is a notable bryozoon. The sections of this zone in Dorset are so poor that bryozoa are not to be reckoned with, so we are quite unable to say if it occurs there; but here this beautiful group, as in all other southern sections, becomes quite a feature of the zone. *Eschara acis*, *Reticulopora obliqua* and *Semicytis rugosa* are found abundantly, but *Heteropora pulchella* is by no means so common as usual. In the Island *Bicavea* (*Lichenopora*) *urnula* is almost a common fossil in this zone, and to a less extent in the base of the zone of *Micraster cor-anguinum.* There is also a slender Vincularia which Mr. Brydone cannot separate from *Vincularia indistincta*, here as elsewhere very abundant at this horizon, though by no means confined to it. The only corals found were *Parasmilia centralis* and *Parasmilia granulata*, the latter being an unusually low occurrence.

It is in these beds, even more than in the zone of *Holaster planus*, that *Serpula* becomes important. *Serpula ilium*, *S. plexus*, *S. ampullacea*, *S. gordialis* var. *serpentinus*, *S. plana*, *S. cincta*, *S. fluctuata* and *S. granulata* all find their place at this horizon. *Serpula ilium* obtains its maximum development here and in the zone immediately below, and the same may be said of *S. gordialis* and *S. cincta*, the latter being the dominant adnate form both in the Wight and elsewhere. *S. macropus*, which is usually fairly common at this horizon, was not found here, and the same applies to *S. plexus* and *S. fluctuata*. All the other forms were abundant. *Serpula cincta* is so abundant at this horizon that it has strong claims to the dignity of a guide-fossil to the zone. It is very rare in the *gracilis*-beds, rather commoner in those of *Holaster planus*, and so common in the zone under discussion that we have sometimes counted as many as a dozen examples on a single echinid, while half that number is quite an ordinary occurrence. Directly we pass into the *Micraster cor-anguinum*-zone, however, this serpula becomes notably rarer, but it persists in diminishing frequency as high as the zone of *Actinocamax quadratus*. We have examined all our echinids from the *mucronata*-zone from every source, including those from Norwich and Trimingham, and have not found a single example. In this our experience is in complete accord with that of Dr. Blackmore. *Serpula granulata* we can now record for every zone in the White Chalk, though it certainly is more abundant here than at any other horizon; and the same may be said of *Serpula gordialis* var. *serpentinus*.

Pleurotomaria perspectiva was found at the base of this zone at Watcombe, and the position is not an unusual one, though it is generally rarer in this zone than in that of *Holaster planus*.

The zone of *Micraster cor-testudinarium* is one of the three central zones which are so rare in the inland chalk of the Island by reason of the fact that quarries are but infrequently opened on the crest of the Downs. The only records given by Mr. Strahan of the exposure of this zone are taken from Dr. Barrois' paper, apparently without verification, and in the main he contents himself with the broad and safe generalisation of Upper Chalk. It may be mentioned that the pit at the foot of Bembridge Down (No. 39) is in the base of the zone of *Micraster cor-anguinum*, and that the roadside section at Arreton Down has long since been grassed over. Mr. Jukes-Browne makes no attempt to separate the zones of *Micraster cor-testudinarium* and *Holaster planus*, but brackets them together, both in the Island and in North Dorset; nor is this custom unknown in the smaller memoirs which illustrate the sheets of various maps of the Geological Survey. The reason for this arrangement is not apparent, for if there are two zones which are conspicuously easy to separate in the field they are the two beds in question. The rigid limitation of *Holaster planus*, *Micraster cor-bovis*, *Micraster leskei* and of the special group-forms of *Micraster præcursor* to the lower zone, and the equally common and characteristic group-forms of *Micraster præcursor* and *Micraster cor-testudinarium* to the upper, afford examples of contrasting critical faunas which it would be difficult to match. This zone yielded a list of only seventy-seven species.

Zone of Micraster cor-anguinum.

Micraster cor-anguinum *Micraster cor-anguinum* var. *latior*	of group-forms peculiar to the zone.	310 ft.
Echinocorys scutatus (a shape-variation peculiar to the zone)		
Echinoconus vulgaris		
Cidaris perornata		
Cyphosoma königi		
Cyphosoma corollare		
Bourgueticrinus ellipticus (a special form)		
Micraster præcursor *Micraster cor-testudinarium*	of group-form restricted to the base of the zone.	

Other characteristic fossils are: *Cidaris sceptrifera*, *Cidaris clavigera*, *Cidaris subvesiculosa*, *Crania parisiensis*, *Thecideum wetherelli*, *Kingena lima*, *Spondylus spinosus*, *Pecten cretosus*, *Vincularia disparilis*, *Idmonea cretacea*, *Plinthosella* and *Porosphæra*.

Micraster cor-anguinum and *M. cor-anguinum* var. *latior*, *Echinocorys scutatus* and *Epiaster gibbus* here conform to the customary shape-variations, and differ in no way from the usual numerical proportions, save that *Micraster cor-anguinum* var. *latior* and *Epiaster gibbus* are apparently rarer than usual; but the sections in this zone are so poor that it would be unwise to dogmatise on this or on any point of distribution. *Echinocorys* is found in the characteristic ovate shape-variation and in the rarer large dome-shaped form. *Micraster præcursor* and *Micraster cor-testudinarium* of the group-form characteristic of the base of this zone may be found *in situ* at Watcombe Bay.

Echinoconus in its shape-variations corresponds with those found on the coasts of Dorset and Sussex, being of the forms known as *Echinoconus vulgaris* and more rarely *E. conicus*. We have, however, found one example which belongs to *E. albogalerus*. This urchin has a tendency to run in bands, one of which is seen in a surface at the edge of the cliff on High Down.

The Cidarites reach in this zone a degree of profusion and differentiation which they have hitherto failed to obtain. *Cidaris perornata* becomes so universally common that it must be regarded as a guide-fossil of definite use in the field, while *Cidaris sceptrifera* for the first time becomes a dominant form, and *Cidaris clavigera* universal in its occurrence. *Cidaris subvesiculosa* practically makes its appearance at this horizon, though we have noted its sporadic occurrence in the three zones immediately below, and it then ranges up to the top of the Chalk. The ever-present *Cidaris hirudo* calls for no comment. This is the zone which has yielded all the perfect examples of Cidarites which are seen in our museums throughout the country, a fact due, not only to the abundance of the remains, but also on account of the massiveness of the chalk, the thickness of the zone and consequent wide distribution in the home counties. All these species occur n the Isle of Wight.

Infulaster rostratus, always a rare fossil in the southern counties and never found below this horizon, was represented by three examples from High Down and Freshwater Bay. So far as our experience goes, the known range of this echinid is from the zone of *Micraster cor-testudinarium* to the upper part of the zone of *Actinocamax quadratus*. The lowest record consists of one example from the Yorkshire coast and the highest are from the same district. In the Salisbury area, Dr. Blackmore states that it is restricted to the *Marsupites*-band and the base of the *quadratus*-zone, while in Hampshire Mr. Griffith refers it to the *Micraster cor-anguinum*-zone alone. Save at the last-named horizon in Yorkshire it is never anything but a comparatively rare fossil.

Hemiaster minimus also adds to our experience by reason of the occurrence of this urchin at the base of the *Micraster cor-anguinum*-zone at the White Horse, Culver Cliff. We have also another example in our collection from the upper part of the same zone at Northfleet, Kent. We have already alluded to Dr. Blackmore's unique record for the *quadratus*-chalk of Salisbury, so that the only zones in which, so far as we know, it has not been found are those of *Marsupites testudinarius* and *Belemnitella mucronata*. It is common here and elsewhere in the zone of *Rhynchonella cuvieri*, rather common in the *gracilis*-beds, and rarer still in the zone of *Holaster planus* and *Micraster cor-testudinarium*, while above this level it is one of the rarest of fossils. We also note *Holaster placenta* as a local rarity in this zone, though we have one example from the higher beds at Northfleet. As a rule, however, it is found only in the base of the zone, as at St. Margaret's Bay, Dover, where it is by no means rare, and seems to take the place of *Echinocorys*.

Cyphosoma also begins to differentiate at this horizon, for while *Cyphosoma radiatum* ranges up abundantly from the base of the White Chalk to the top of the zone of *Micraster cor-testudinarium*, it is only in the zone under discussion that *Cyphosoma königi*, *C. corollare*, and *C. spatuliferum* really make their appearance in force. All but the last-named were found here.

Hitherto *Bourgueticrinus ellipticus*, though found abundantly, so far as the columnars are concerned, in the four lower zones, has been strangely reluctant to furnish us with a characteristic head, or indeed with any head at all. Throughout these zones the columnars have been notably small, increasing in size and number as we ascend the zonal series. Directly, however, we get well into the present zone they enlarge conspicuously, and large barrel-shaped and long and thick rod-shaped columnars become quite common, but more important still, the head is no longer a rarity, and is fully diagnostic of the zone.

The same emergence of new forms is seen in the brachiopods, for *Crania parisiensis*, *Thecideum wetherelli* and *Kingena lima* cease to be museum curiosities and are among the commonest of fossils. Nor are the lamellibranchs wanting in the elaboration of new species or in zonal variations of old ones; moreover, in all of them there is a notable increase in size and abundance. *Spondylus spinosus* begins in the *gracilis*-beds and becomes larger, more numerous and more inflated as we ascend the zones; but it is here that it reaches a size, and degree of inflation, which render it the beautiful fossil so often seen in our museums. *Lima hoperi*, too, is notably larger and more common. *Ostrea* also, hitherto only represented in any quantity by *Ostrea vesicularis*, *O. hippopodium* and *O. semiplana*, now adds the forms of *O. lateralis*, *O. normaniana*, and *O. wegmanniana*, which, if not new, have as yet been but insignificantly represented. All these are both commoner and larger than in the zones below. *Pecten cretosus*, a rare fossil in the lower zones, becomes now abundant and of large size, and ranges up without a break to the top of the *mucronata*-chalk in Dorset, Hampshire and the Isle of Wight. In the Salisbury area, however, Dr. Blackmore states that in the *mucronata*-zone *Pecten mantellianus* completely displaces *P. cretosus*. At Norwich and Trimingham, on the other hand, the two forms occur together.

Inoceramus cuvieri also, though by no means a new or rare species, ranging up as it does from the *gracilis*-beds, here universally reaches its climax in point of quantity and probably in point of size. In the Island, where the zone is so badly displayed, it is often our most reliable guide, for the bedding-planes are sheeted with it and the talus littered with its fragments.

Among the free bryozoa *Vincularia disparilis*, *Truncatula aculeata* and *Idmonea cretacea* most readily catch the eye and they are especially useful as they are rare fossils below this horizon and now for the first time became prominent forms. Moreover, other species, such as *Eschara acis*, *Semicytis rugosa* and *Heteropora pulchella*, which have crowded the chalk in the two zones immediately below, now sink into insignificance. This general description applies to the Island also.

Probably one of the rarest fossils found in the Island is

Aptychus portlocki, a small example of which, with both valves intact, was obtained at this horizon at Watcombe Bay.

Serpula turbinella makes its first appearance in this zone, and hereafter ranges to the top of the White Chalk in increasing size and number; *Serpula ampullacea* is much larger and more abundant; and *Serpula plexus* also for the first time becomes a common form, though we failed to find it in the Island. A curious local feature at Freshwater Bay is that the base of this zone is crowded with *Serpula ilium*. The last-named is never a zonal fossil, save that it is abundant at certain horizons, for it ranges throughout the White Chalk.

The corals also follow suit, for instead of the rather dwarfed forms, almost restricted to *Parasmilia centralis*, we have *Parasmilia centralis* var. *gravesana*, *Parasmilia granulata*, *Parasmilia cylindrica*, *Parasmilia mantelli*, *Parasmilia fittoni*, and more rarely *Caryophyllia cylindracea*, *Stephanophyllia michelini*, *Epiphaxum auloporoides*, *Synhelia sharpeana*, *Diblasus gravensis* and the robust form of *Onchotrochus serpentinus* before mentioned. So far as the Island is concerned the corals are but poorly represented.

Even the sponges offer new forms at this horizon, for it is the first time, save in Sussex, that globular flints, rich in the remains of the genus *Plinthosella*, are a feature. Here also *Stichophyma tumidum*, *Pachinion scriptum*, *Doryderma ramosum*, *Siphonia königi*, *Porochonia simplex*, *Verrucocœlia tubulata*, *Leptophragma murchisoni*, *Polyblastidium racemosum*, *Placotrema cretaceum*, and *Pharetrospongia strahani* first claim our attention either by reason of a newly found abundance or as fresh introductions. *Ventriculites radiatus*, ranging up from the base of the White Chalk, also becomes much larger and commoner. But it is with the valuable group of *Porosphæra* that we are specially concerned. *Porosphæra globularis* increases in size and number as we ascend the four lower zones, but even in the zone of *Micraster cor-testudinarium* is rarely more than 8 mm. in diameter. No sooner, however, do we pass beyond the lower one-fourth of the zone under discussion than the size greatly increases, and the forms known as *P. pileolus*, *P. nuciformis*, *P. patelliformis* and *P. arrecta* become quite a feature of the zone. *Porosphæra pileolus* and especially *P. nuciformis* are quite rare fossils even in the zone of *Micraster cor-testudinarium*. In the Island the sponges at this horizon are characteristic and fairly well represented, and *Porosphæra* conforms to the distribution which we have just indicated.

We were well satisfied to be able to record ninety species for this zone.

Zone of Marsupites testudinarius.

Marsupites testudinarius	*Marsupites*-band average thickness, 44 ft.
Echinocorys scutatus (a special pyramidal form)	
Bourgueticrinus ellipticus (a special form)	
Terebratulina rowei	
Caryophyllia cylinaracea	
Uintacrinus	*Uintacrinus*-band average thickness, 43 ft.
Echinocorys scutatus (a special pyramidal form)	
Bourgueticrinus ellipticus (a special form)	
Terebratulina rowei	
Caryophyllia cylindracea	

Other characteristic fossils are *Micraster cor-anguinum*, *Echinoconus vulgaris*, *Cyphosoma königi*, *Ostrea wegmanniana*, *Serpula turbinella* and *Porosphæra*.

It may be said at once that, being in flinty chalk, the zone here contains no "Bedwell-line," that there are no bands of *Echinocorys* or *Echinoconus*, and that Ammonites and Belemnites are entirely wanting. In all these respects the zone corresponds with that on the Dorset coast, and, as before, we divide the zone proper into the usual two sub-zones. Once again we return to the question of the name-fossil for this zone, as there are some who claim that the sub-zones should be elevated to the full zonal dignity, for the reason that *Marsupites* and *Uintacrinus* are, save at the point of immediate contact, rigidly confined to their respective levels, and that the cephalopods, when present, are equally restricted in their range. Our answer to this criticism is that the cephalopods may be absent, as in Hampshire, Dorset, and the Isle of Wight, and that a zone is characterised even more by its associated guide-fossils than by its name fossil. An horizon which is characterised throughout by the presence of the characteristic sub-pyramidal shape-variation of *Echinocorys*, the characteristic head of *Bourgueticrinus*, and *Terebratulina rowei*, even though *Marsupites* be restricted to its upper part, and *Uintacrinus* to its lower, so distinctly fills our ideal of a critical zonal fauna that we are more than content to adhere to the scheme herein set forth.

The shape-variations of *Echinocorys scutatus* are identical with those at the same horizon elsewhere, the characteristic sub-pyramidal form being fully diagnostic of the zone as a whole, while at the base it gives the usual passage-forms connecting it with the ovate shape-variation in the zone below, and at the top the equally common passage-forms linking it on to the gibbous shape-variation of the *quadratus*-chalk. Our only dome-shaped form was a broken example in the *Uintacrinus*-band of Freshwater Bay.

Bourgeticrinus is illustrated by the same nipple-shaped head and thick barrel-shaped columnar, which are found in every section in the south of England,* but they are not so common here as in other districts, mainly by reason of the fact that the sections in the Island are so poor. Mr. Griffith and Mr. Brydone found both these characteristic crinoid remains in the Island.

Among other brachiopods common at this horizon we note in the Island *Terebratulina rowei*, *Terebratulina striata*, *Crania egnabergensis*, *Crania parisiensis*, *Rhynchonella plicatilis*, *Rhynchonella reedensis*, *Thecideum wetherelli*, and *Kingena lima*. The last named was of the usual small, rounded form seen in this zone, but was here unusually rare. *Rhynchonella plicatilis*, so abundant in Sussex, was rare here, coinciding with the scarcity in Dorset and Kent at this horizon.

The Lamellibranchs present no unusual feature, save that the bands of *Ostrea vesicularis* and *Ostrea wegmanniana*, which are usually quite a feature of the zone, are here but poorly shown. We found one example of *Lima decussata* in Pit No. 92 in the *Uintacrinus*-band. As usual, *Lima hoperi* reaches its maximum size at this horizon.

Terebratulina rowei was found in every section on the coast in which the sub-zones were displayed, as well as in the old road at Freshwater Bay and the small exposure at the cliff edge at Tennyson's Monument. Though we obtained three examples in the extreme base of the *quadratus*-zone we found it here rigidly confined in its downward range to its own horizon, and have never met with it in the zone of *Micraster cor-anguinum.*

Caryophyllia cylindracea we usually regard as a form limited to this zone, and even more particularly to the *Marsupites*-band; but in the Island we obtained it in both the sub-zones. Dr. Blackmore does not find it so restricted in the Salisbury area, but gives it a range from the zone of *Micraster cor-anguinum* to the base of the *quadratus*-chalk.

The shape-variations of *Echinoconus* resemble those in Dorset and Sussex. We found few uncrushed examples, but such as we saw were referred to the round form known as *Echinoconus vulgaris*, together with one undoubted example of *Echinoconus globulus.* This urchin is rare in Hampshire at this horizon, but it occurs in a scattered band at the base of the zone at Salisbury, where the shape-variations appear to coincide with those in Kent, in that *E. conicus* and *E. albo-galerus* are both obtained. We record *E. globulus* from both the *Uintacrinus*-band and the top of the *Micraster cor-anguinum*-zone in Thanet, and from the latter horizon at Northfleet.

Micraster cor-anguinum is by no means common here, and the material is too scanty and damaged to warrant one in saying that the var. *rostratus* is the characteristic form. This variety is more common at Salisbury than it is at Margate. *Cyphosoma*

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* *Proc. Geol. Assoc.*, vol. xvi, Pl. viii, 1900. Part I, Kent and Sussex.

königi here reaches its largest size, and we found it in both sub-zones at Freshwater Bay and Scratchell's Bay. *Cardiaster pillula*, one example of which was found in the *Marsupites*-band at White Nothe, Dorset, was not seen here—a further proof, were it needed, that this urchin is one of the rarest occurrences in this zone. *Serpula turbinella* is more common than in the zone immediately below, but it is not until we reach the two highest zones that it becomes really common and large.

The large size of *Porosphæra globularis*, so helpful in the field in Kent and Sussex, is hardly so conspicuous here, though it attains goodly dimensions, and is certainly bigger than the examples found in the zone immediately below.

The *Uintacrinus*-band contributed a list of only forty-eight species, and *Marsupites*-band but fifty-nine. All who work these sections will realise the reason for a scanty fauna.

Zone of Actinocamax quadratus.

We are in the habit of alluding to the barren areas in the *quadratus*-chalk, and those who examine the beds at this horizon in the Island will appreciate the significance of the term.

Echinocorys scutatus (a characteristic gibbous form)	average thickness 371 ft.
Cardiaster pillula	
Bourgueticrinus ellipticus (a special form) . .	
Actinocamax quadratus	
Actinocamax granulatus	
Cælosmilia laxa	

Other characteristic fossils are: *Rhynchonella limbata*, *Rhynchonella plicatilis*, *Terebratulina rowei*, *Crania egnabergensis*, *Eschara acis*, *Vincularia santonensis*, *Cribrilina* sp., *Serpula ilium*, *Serpula turbinella*, and *Porosphæra*.

It is with considerable misgiving that we print the tabular summary given above, for in the Isle of Wight *Cardiaster pillula* and the two belemnites are conspicuously rare. Indeed, one may state unreservedly that *Echinocorys*, *Bourgueticrinus* and the bryozoa are here the only reliable guides in the field.

Echinocorys scutatus, if it were more abundant and less shattered, would be all-sufficient for our purposes, for the gibbous form with a flat base is a really reliable zonal guide throughout the whole of southern England. It tends to run in bands, and the only drawback is that the bands are often reprehensibly far apart. There would appear to exist here the rather pointed and dome-shaped form which we have previously mentioned, and also a certain number of very depressed forms of medium size. All these shape-variations exist in other southern sections, but here the rock is so shattered that shape-variations are not easy to follow with certainty.

Cardiaster pillula was abundant in Dorset and Sussex, and appears to be equally common in Hampshire and the Salisbury area. In all these localities it runs in bands. Here, however, it is so rare as to be useless as a zonal guide, and we give on p. 283 a list of sections where it has been found. Had the sections in this zone a better surface it is quite possible that this echinid might be found in its usual abundance, and the suggestion gains point from the statement by Mr. Griffith that, when the excavation for the fort at the Needles was being made, he and Mr. Brydone collected there a considerable number of examples. However, Mr. Griffith entirely shares our views as to the rarity of this urchin in the Island and its consequent lack of value as a guide-fossil. Moreover, its usefulness as a zonal guide is further complicated by the fact that in the Island it is also found, though very sparingly, in the *mucronata*-chalk.

Here also, as in Dorset, we found portions of *Micraster coranguinum*, two at Scratchell's Bay, two at Freshwater Bay, and one at White Cliff Bay, so that in time examples will probably be obtained in a sufficiently perfect state to establish the much-needed essential features of the test for this zone in England. We have found it in the base of the zone in Sussex and the Portsdown Hills, and well up in the zone at Bessingby, near Bridlington; but it finds no place in the collections of Mr. Griffith and Dr. Blackmore.

The belemnites are interesting in that they occur here in the same position in the zone as in Dorset; but with that their usefulness ends, for we have but seven examples of *Actinocamax quadratus* and three of *Actinocamax granulatus* to reward us for nine weeks' work in the Island. It must be remembered, however, that but for the fortunate occurrence of the former belemnite in horizontal chalk, east of White Nothe, where it occupied a bed of only some 20 ft. in thickness in the middle of the zone, we should probably be in the same case as in the Island; for it will be readily understood that if we convert this horizontal into vertical chalk, we might easily pass over this limited vertical surface without seeing a trace of a belemnite. The even greater rarity of *Actinocamax granulatus* is readily accounted for by reason of the fact that it is confined to a still narrower bed at the base of the zone. It was found in exactly the same position in Dorset and was equally rare.

While speaking of Cephalopods it may be well to remember that, as in Dorset, no Ammonites or Aptychi were found in this zone. Mr. Griffith finds both *Aptychus leptophyllus* and *Aptychus portlocki* in Hampshire, and Dr. Blackmore has a wonderful series of the same two species from the Salisbury area. In the latter locality *A. portlocki* is of a small and lamellate type, and *A. leptophyllus* is rigidly confined to a narrow bed to which *Belemnitella lanceolata* is also restricted.

Bourgueticrinus ellipticus is always a useful guide, for the head is fully characteristic, and the columnars with their expanded ends are abundant. These are figured in Part I., Kent and Sussex.* This species is well exhibited in the Island.

The brachiopods in this zone are, as usual, interesting. *Rhynchonella plicatilis* is common here, as elsewhere, and so is the form known as var. *octoplicata*; while *Rhynchonella limbata* is abundant, and is useful in the field in that its shape-variation differs from that in the *mucronata*-chalk, being larger, broader and more plicate at the margin. *Crania egnabergensis*, though less common than usual here, is of good size and with costæ rather wide apart; and *Terebratulina rowei* was represented by three examples in the extreme base of the zone at Scratchell's Bay, just as on the coasts of Dorset and Sussex, and in the Portsdown Hills and at Salisbury.

It is useless to deal dogmatically with lamellibranchs in this shattered and obscured chalk. *Inoceramus lamarcki* is found, and would appear to be of smaller size than the form so commonly seen in the zone of *Micraster cor-testudinarium* and to a less extent that of *Holaster planus*. We found *Ostrea lateralis*, but not the interesting form known as the var. *striata*, which we regard as so characteristic of this zone. In any case, it is only at the last-named horizon that this variety is at all common. Quite, recently, however, we have been able to extend our knowledge of its vertical range by the occurrence of three solitary examples from other zones, for Dr. Blackmore has found it in the *mucronata*-chalk of Alderbury, Salisbury; Mr. H. J. Osborne White has seen it in the *Micraster cor-anguinum*-zone at Boxford, Berkshire; and we have obtained it in the *Micraster cor-testudinarium*-zone at Dover. Mr. Osborne White has also recently sent us a portion of an *Ostrea* with practically identical ornamentation, save that the striæ are slightly coarser. It was found by Mr. F. J. Bennett in the *Rhynchonella cuvieri*-zone, a little above the Melbourn Rock, near Bunker's Farm, Birling, Kent. The fracture is that of an oyster and not of an *Inoceramus*. If our determination of this fragment be correct, the record is a remarkable one. *Septifer lineatus* is, strange to say, a new appearance in our lists, for we have never yet seen it on the coast; but here we obtained two examples in pit No. 14, Shalcombe. Dr. Blackmore only finds it in the zones of *Marsupites testudinarius*, *Actinocamax quadratus* and *Belemnitella mucronata* at Salisbury; while Mr. Griffith lists it in the Chalk Rock and *quadratus*-chalk of Hampshire; and Mr. G. W. Young has found it in the *Marsupites*-band at Great Woodcote, Surrey. Our only other example was collected in the Cenomanian limestone of Beer Head, and was remarkable for the preservation of the nacreous layer of the shell. It has also been found in the *Micraster cor-anguinum*-zone at Northfleet, Kent.

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* "The White Chalk of the English Coast." *Proc. Geol. Assoc.*, vol. xvi, Pl. viii.

Bryozoa are often abundant in this zone, forming bands, as in the base of the zone on the Sussex coast and in the Portsdown Hills. The sections in the Island are too obscured to enable one to say if the same conditions obtain here, but by breaking up blocks characteristic forms are often found. Even here we still find that *Eschara acis*, *Vincularia santonensis*, and *Cribrilina* sp. are useful guides in the field.

The corals in this zone are usually interesting, for apart from the abundant and highly characteristic *Cœlosmilia laxa*, we generally expect to find *Parasmilia centralis*, *P. cylindrica* and *P. fittoni*. The two latter were not seen here, but *P. centralis* is not altogether rare. However, here as elsewhere, *Cœlosmilia laxa* is the dominant form, and is both common and remarkably large.

When dealing with the coasts of Sussex and Dorset we noted that *Serpula ilium* in this zone was both abundant and of unusually large size, and we still regard this evidence as useful in the field. In addition, we found two aggregations of this annelid, which must be regarded either as an abnormally large form of *S. ilium*, or a very thin form of *Serpula plexus*. As usual, *Serpula turbinella* becomes in this zone an increasingly important fossil, both numerically and in point of size.

The *Porosphæra* group is also of value. *Porosphæra globularis*, though of good size, is smaller than in the *Marsupites*-zone, while *Porosphæra nuciformis* is both larger, and with grooves and point more accentuated than in the zone below. *Porosphæra pileolus* here reaches its maximum in size and number. All these features are seen in the Isle of Wight.

We are fully satisfied to have obtained a list of 62 species in chalk so barren and ill-exposed.

Zone of Belemnitella mucronata.

Belemnitella mucronata
Echinocorys scutatus (a special form)
Cardiaster ananchytis
Cidaris serrata
Cidaris pleracantha
Bourgueticrinus ellipticus (a special form)
Pycnaster angustatus
Magas pumilus
Crania costata
Kingena lima (a special form)
Rhynchonella limbata (a special form)
Terebratula carnea
Inoceramus sp.
Cœlosmilia laxa
Serpula canteriata

Maximum combined thickness in Scratchell's Bay and Alum Bay, 475 ft.

Other characteristic fossils are: *Cardiaster pillula*, *Cidaris subvesiculosa*, *Salenia geometrica*, *Aptychus portlocki*, *Lima granulata*

Pecten campaniensis, *Porina filiformis*, *Eschara acis*, *Vincularia santonensis*, *Vincularia bella*, *Semieschara woodsi*, *Semieschara arborea*, *Serpula sexangulata*, *Serpula turbinella*, *Porosphæra*, *Leptophragma murchisoni*, and *Aphrocallistes*.

This is indeed a formidable summary and one which differs in many notable respects from the lists obtained in other southern counties, and even from that of the Dorset coast itself. We give our zoological data just as they occurred to us in the field and have made no attempt to force a closer correspondence between this chalk and that of Dorset. Indeed, the very variations, within a distance so short, stimulate the interest and make conclusions the more real. It is a relief to pass from the apparently barren *quadratus*-chalk to a zone which, on the coast at any rate, exhibits a fauna which is as rich as it is convincing. We must frankly admit, however, that in quarries, especially such as those which we found in the Island, the fauna is by no means easy to obtain. Still, we have yet to see a section in this zone where one of the guide-fossils at least was not forthcoming. If only the *mucronata*-chalk in the Isle of Wight were soft and horizontal, what a record of exuberant life it would yield.

Belemnitella mucronata is unquestionably scarcer here than in Dorset, even on the coast, but in size and general appearance the guards correspond entirely. As in the vertical beds of the Chalk Ridge in Dorset, we search quarry after quarry in succession without seeing a trace of the belemnite; but whereas in Dorset *Magas pumilus* frequently came to our aid, here we had, by reason of the rarity of this interesting little brachiopod, to rely on *Echinocorys scutatus* alone.

It will be noticed that *Belemnitella lanceolata* is omitted from our list of guide fossils for this zone. We do this because we have considerable doubt if the narrow tapering form, which we have hitherto referred to this species, is not really the narrow shape-variation of *Belemnitella mucronata*. There are in every zone of the White Chalk in which they occur, both in the case of *Actinocamax* and *Belemnitella*, two sharply contrasting forms, the one long, narrow and tapering, and the other short and inflated. The difference may be varietal or even sexual, and the two forms occur not only in the same zone but in the same stratum. The points which distinguish *Belemnitella lanceolata* from *Belemnitella mucronata* are, apart from the fact that the shape of the former is thin and tapering, a slight inflation at the junction of the middle and distal one-third, and a smoother guard, due to a decrease in strength of the vascular impressions. We have before quoted Dr. Blackmore as stating that *Belemnitella lanceolata* is restricted at Salisbury to a comparatively narrow bed in the lower two-thirds of the *quadratus*-chalk, wherein it is associated with *Aptychus leptophyllus*, which is also limited to the same restricted horizon. Quite recently we have had the opportunity of examining Dr.

Blackmore's unrivalled collection of Belemnites, and the study of this series, together with our own observations in the field, leads us to the conclusion that the true *Belemnitella lanceolata* is only found in the narrow bed of *quadratus*-chalk at Salisbury, and that the narrow tapering forms found in the *mucronata*-chalk are only a shape-variation of *Belemnitella mucronata.* A more extended knowledge of the genus may alter this opinion, but this is certainly our view from the material at our disposal up to the present time.

Before we leave the Cephalopoda we may as well state that we found no trace of an Ammonite in this zone, either in the Island or on the Dorset coast. They occur rarely, however, in the *mucronata*-chalk of Norwich and Salisbury, but we do not know to what species they should be referred.

We recorded *Aptychus rugosus* from Dorset, but failed to find it here, but in its stead we obtained the larger and smoother form of *Aptychus portlocki*, two examples at Scratchell's Bay and one at Whitecliff Bay. At Salisbury, and in Hampshire *Aptychus rugosus* is the dominant form of the *mucronata*-zone; but Dr. Blackmore has two examples of *Aptychus portlocki* of the large and smooth form from the same horizon, and we have also collected another from the Salisbury area. It must be conceded, however, that the true horizon for *Aptychus portlocki* is the *quadratus*-chalk, and that in the latter zone the valves are smaller and more lamellate.

Echinoderma is here an all-important group and obtains a rich development, but, owing to the hardness of the rock, nothing is found in a perfect state, nor can the fossils be properly cleaned.

Echinocorys scutatus is abundant, and, so far as we can ascertain from our mutilated material, occurs in three principal shape-variations. The form, which is alike the commonest and most useful in the field, is the small pyramidal shape-variation resembling *Echinoconus conicus* in outline, and of very much the same size. It is happily very abundant, for, as we have before mentioned, we have often to rely on it entirely in fixing the age of the chalk on the northern limit of the Chalk Ridge. Even in a small form such as this a perfect example is quite a rarity, and the best examples are those which are in-filled with flint. It probably runs in bands, as in Dorset, for though we have here no section in horizontal chalk in which we can trace it, individual fallen masses often contain many examples; as an instance of which we may state that one small block at Whitecliff Bay contained eighteen examples on the surface alone. We have found this small pyramidal form at the extreme base of the zone, and at its contact with the Eocene, both in Dorset and the island, and it occurs abundantly, so far as we can tell, at all the intermediate levels. The same form is equally characteristic of the zone in Hampshire and Wiltshire.

There is a large form which assumes the shape of a slightly pointed dome, thereby closely resembling the well-known shape-variation found at Norwich. We have as yet failed to get a perfect example, but crushed specimens are by no means rare. Professor John Milne has two very large examples from the Shide Quarry (No. 49) which are practically perfect.

Another interesting variety is that in the shape of a tall, rounded dome, much compressed laterally. We found it at Scratchell's Bay, Alum Bay, and pits No. 61, Apes Down, and No. 105, Mount Joy. The very small forms with thin test, which we record at Ballard Head, was not found here, but since the publication of the Dorset Paper we have collected it at Norwich, and examples may be seen, both in calcite and as flint casts, from the gravels, in the fine museum in that city. By no means the least interesting find in this zone was that of three immature examples of *Echinocorys*, measuring but 2 mm. in diameter. The only other similar instance with which we are acquainted is in Dr. Blackmore's collection, where nine examples were found inside a full grown *Echinocorys*. The scarcity of very young forms is always a source of wonder in the field, but it is probable that diligent search would result in a better knowledge of the subject.

Cardiaster pillula is another new record in our experience of *mucronata*-chalk, and is generally of a small and rounded shape. It is not merely found in the base of the zone, for we have collected it at the Eocene junction at Alum Bay, at pit No. 49, Shide, at No. 41, Brading Station, as well as at the middle of the zone at Scratchell's Bay. It probably occurs at the same horizon in Hampshire, but not in the Salisbury area, and Mr. Brydone says that he has found it at the same level in Suffolk.

Cardiaster ananchytis, though by no means a rare fossil, is always broken, both on the Dorset coast and in the Island, while its absolute restriction to this zone makes it a reliable guide-fossil. The only exception to this rule with which we are acquainted is in Yorkshire, where it ranges from the zone of *Micraster cor-anguinum* to that of *Actinocamax quadratus*, being an abundant fossil at the latter horizon. So far as we know there is no *mucronata*-chalk in that county.

Before leaving the irregular echinids it is well to mention that a solitary example of *Echinoconus conicus* has been found by Mr. Walter P. Young close to the junction with the Eocene at Alum Bay. The occurrence is not entirely new, however, as Mr. Mark Norman records it from the same locality, and possibly this specimen may be in the Ventnor Museum. Mr. Young's example could not be told from a characteristic Northfleet form from the zone of *Micraster cor-anguinum*, for it is of medium size, conical, flat in base, and with an anus large and marginal. Anything more unlike the depressed form which is found at Norwich it would be difficult to imagine.

Micraster, as in Dorset, was represented by a portion of a test found at Scratchell's Bay. It is not found in Hampshire or in the Salisbury area, but we have collected it at Norwich, Weybourn, and Trimingham, where it is always a rare fossil.

Of the regular echinids we note *Cyphosoma königi*, *Cyphosoma corollare*, *Salenia granulosa*, and *Salenia geometrica*, the three former being unusually high occurences, for we believe that neither Mr. Griffith nor Dr. Blackmore has recorded them from this horizon. *Salenia* was not found in Dorset.

The Cidarites, as at Ballard Head and Studland Bay, are here of peculiar interest, the characteristic form being *Cidaris serrata*, which is the more valuable as a guide-fossil in that it is restricted to the *mucronata*-chalk. The universally prevalent *Cidaris hirudo* is here found in abundance, and *Cidaris subvesiculosa* is also fairly common. We did not see any spines of *Cidaris serrata* with triple denticles, as in Dorset, nor did we find the spines of *Cidaris*, sp. nov., which we mention on p. 62 of the Dorset paper. We have never seen *Cidaris sceptrifera* or *Cidaris clavigera* in this zone, though we have found them both in the lower part of the *quadratus*-chalk on the Sussex coast.

The chief interest, however, centres round *Cidaris pleracantha*, the spines of which we have already recorded for the Dorset Coast, where we found four examples. Here we were fortunate enough to secure seven specimens, all, however, in a poor state of preservation. Those from Dorset were found in the upper one-third of the zone, while those from Scratchell's Bay came from the lower half, so that it is possible that it ranges sporadically throughout the *mucronata*-chalk.

It would occupy too much space to give a description of the spines by the various authors, so we content ourselves with giving the following references :

AGASSIZ.—*Cat. Syst. Ectyp. Foss.*, p. 10, 1840.
SORIGNET.—*Oursins Foss. de l'Eure*, p. 4, 1850.
DESOR.—*Synops. des Échin. Foss.*, p. 14, Figs. 7-10, 1856.
COTTEAU.—*Pal. franç. Ter. Crét.*, p. 310, Figs. 1-13, 1865.
WRIGHT.—*Pal. Soc., Mon. Brit. Foss. Ech.*, p. 67, Pl. XI, Fig. 5, Pl. XII, Fig. 5, 1864-1882.

We have been at some pains to work out the French and English occurrences of this rare species, so we give them in detail in order that we may show how the wide gap between the zones of *Holaster subglobosus* and *Belemnitella mucronata* has been closed up by further collecting and inquiry. Sorignet is the only writer who claims to have found the test of this urchin, and there would seem to be some doubt as to the determination of his specimen. The other authors content themselves with stating that the test is unknown; nor have we been any more fortunate, though we have made special search for it. The known occurrences, so far as our investigation goes, are as follow:

Belemnitella mucronata	Meudon (Agassiz, Desor, Cotteau).
Belemnitella mucronata	Dorset and Isle of Wight (Rowe).
White Chalk of Civières (Eure)	(Sorignet).
Actinocamax quadratus	Spettisbury, near Blandford (*Mus. Pract. Geol.*, No. 20370).
Upper White Chalk of Sussex	(Desor).
Micraster cor-anguinum	Arreton (Isle of Wight), (Barrois).
Micraster cor-anguinum	Northfleet (*Sedgwick Mus.*).
Micraster cor-anguinum	Thanet Coast (*Rowe Coll.*).
Holaster subglobosus	Sussex and Dorking (*Brit. Mus. Nat. Hist.*).

The Agassiz types (casts) can be seen at the Brit. Mus. (Nat. Hist.), and our examples from Dorset and the Island conform closely to them. The original spines from which the casts were taken came from Meudon. We have been unable to ascertain the zone of the White Chalk of Civières. The examples from Spettisbury, Northfleet, and those from the Grey Chalk of Sussex and Dorking have all been examined and we have no doubt as to their determination. The zone of the Arreton example is doubtful, for though Dr. Barrois records it under the heading of the *Micraster cor-anguinum*-zone, a glance at his list of fossils (*op. cit.*, p. 25) leaves us with the suspicion that the zones of *Marsupites* and *Actinocamax quadratus* are here, as in other localities, coupled with the zone in question. The reference to the upper White Chalk of Sussex would seem to indicate the zones of *Marsupites* and *Actinocamax quadratus* also. In any case, it is clear that we have been able to bridge-over several hundred feet of the gap between the highest and lowest occurrences hitherto recorded.

Bourgueticrinus yet again appears as a guide-fossil for this zone, for we had the good fortune to find several heads of this crinoid both at Ballard Head and Scratchell's Bay. The head is practically indistinguishable from that characteristic of the *Marsupites*-zone. When we first found it in Dorset we thought that it differed from that in the lower zone, but a larger series of specimens would seem to bring the two forms into line. The columnars, however, differ widely from those in the *Marsupites*-zone, for they are small, contracted in the centre, and with excavated articular surfaces. We have made inquiry and find that the head in this zone is unknown to other collectors. We have also examples from Trimingham, which closely resemble those from the *mucronata*-chalk of the Island.

The separate ossicles of Asteroidea are for once a useful guide in the field. We know that the different genera and species have their zonal restrictions, but specimens with connected ossicles are so rare, save in quarries, that those who work on the coast find them of no zonal value whatever. Dr. Blackmore's magnificent collection of perfect examples from Salisbury and Micheldever, however, have enabled him to use the separate ossicles as zonal guides, and we have obtained his assistance with those mentioned in this paper. Mr. Spencer in the forthcoming addition to his monograph will figure the characteristic marginal ossicles, so that they will then be available for use in the field. We find that our references to *Calliderma latum* and *Oreaster bulbiferus* as guide-fossils to this zone in Dorset was a mistake, and Dr. Blackmore and Mr. Spencer refer them to *Pycnaster angustatus*. Here, as in Dorset, these large ossicles are quite numerous, and as they readily catch the eye, we have no hesitation in employing them as fossils locally characteristic of the zone, for at no other horizon have we found them so large or so numerous.

Brachiopods are again of high importance as guide-fossils, for *Magas pumilus*, *Crania costata*, *Kingena lima*, *Rhynchonella limbata, and Terebratula carnea* are all of definite service in the field. They are all abundant in the Island.

Magas pumilus has never to our knowledge been found below the *mucronata*-zone, and is, therefore, when found, an absolutely safe guide to horizon. Unfortunately, it is erratic in its incidence, especially in the Isle of Wight. In Dorset we found it at the base of the zone at Arish Mell, and abundantly in the upper portion at Ballard Head and Studland Bay, and in the horizontal chalk at Wool. Here it is quite common at Alum Bay, at the junction with the Eocene, and not rare at pits No. 1 and 2, Freshwater. The other occurrences are noted on p. 284. We did not find it at the base of the zone at Scratchell's Bay. At Salisbury Dr. Blackmore has only found three examples, measuring 4 mm. in diameter, while Mr. Griffith does not record it for Hampshire. We have it at Norwich, Weybourn, and Trimingham.

Rhynchonella limbata, though it has an unbroken range from the zone of *Terebratulina gracilis* upwards, is here fully characteristic of the *mucronata*-chalk, for it is of the small inflated form known as *Rhynchonella lentiformis*, Woodward. For further information on this point see our paper on the Dorset coast, pp. 63 and 64.

Kingena lima has also a characteristic shape-variation, being large and pentagonal. The shape is rounded in the *Marsupites*-zone, somewhat pentagonal in the *quadratus*-zone, and strongly so in that of *Belemnitella mucronata*. The largest specimens which we have ever seen come from the *quadratus*-chalk of Harnham, Salisbury.

Crania costata is equally reliable as a zonal guide, for it is in our experience absolutely restricted to this horizon. It is rarer here than in Dorset. Hitherto, we have never seen a single example of *Crania egnabergensis* in this zone, but we can now record a solitary example from Whitecliff Bay. The reference to *Crania costata* is G. B. Sowerby, "Genera of Recent and Fossil Shells," No. xii, fig. 6, 1823.

Terebratula carnea is not of large size, but is fairly common here, and is of the form found at Meudon and characteristic of the zone. This is the only zone in the White Chalk where it is not accompanied with the equally common *Terebratula semiglobosa*. Both at Salisbury and in Hampshire this condition holds good, but at Norwich we find, out of hundreds of examples, about 2 per cent. where the shell is narrower and the margin distinctly plicate. This is not due to distortion, and, though slight, is clearly a survival of the marked plication in the examples from the *quadratus*-beds below, where, curiously enough, *T. semiglobosa* would appear to be commoner than *T. carnea*.

Rhynchonella plicatilis is decidedly rare here, and of small size. It occurs at Salisbury, in Hampshire, and on the Dorset coast, and in the first locality the size is also small. The maximum in point of size seems to be reached in the zone of *Holaster planus* in most southern sections, the dimensions diminishing as we ascend the zones. The obvious exception to this statement is the *mucronata*-chalk of Norwich, where the shell is as large as any found in the *Holaster planus*-zone. We did not see the var. *octoplicata* here.

Rhynchonella reedensis, which found no place in our list for Dorset, is rather common here. Dr. Blackmore and Mr. Griffiths record it for the same horizon at Salisbury and in Hampshire respectively.

Thecideum wetherelli is by no means common, but this may be due to the fact that, owing to the hardness of the rock, all adnate forms are rare. It has a range from the zone of *Micraster cor-testudinarium* to the top of the White Chalk, being notably rare at its lowest limit. At Scratchell's Bay we found two examples of large size, with a deep sulcus in the tall adnate valve. This variety was quite new to us, but we find that Dr. Blackmore has several examples from the same horizon at Salisbury. There is a close resemblance between these larger forms and *Thecideum vermiculare* from Trimingham.

Lamellibranchs here are by no means so useful as zonal guides, but those which are of value in the field are *Inoceramus* sp., *Pecten campaniensis* and *Lima granulata*. The genus *Ostrea* here seems to exhibit no zonal feature.

Inoceramus sp. is so useful in the field that we the more regret our inability to trace it in any of the works to which we have access. In our experience it is entirely limited to this zone, and is common throughout its entire extent. Dr. Blackmore regards it as equally common at Salisbury, and equally distinctive of horizon.

Pecten campaniensis is rare here, as we only found it at Alum Bay and Pit No. 6, High Down. Dr. Blackmore gives it a range from the *Uintacrinus*-band to the *mucronata*-zone at Salisbury, and it is also found at Norwich and Trimingham. Until the publication of Mr. Wood's monograph, most English workers had confounded this form with *Pecten pulchellus*, which we now know is confined to the Trimingham Chalk. Quite recently we have been able to extend the range of *Pecten campaniensis* in a downward direction, for we have found five examples in the *Micraster cor-testudinarium*-zone of Dover.

Pecten cretosus, always broken, both here and in Dorset, is of moderate size and fairly common. It ranges from base to top of the White Chalk, the largest examples being found in the *quadratus*-zone and at Norwich. Curiously enough, it is not found in the *mucronata*-zone at Salisbury, where it is replaced by *Pecten mantellianus* (*olim concentricus*). We did not find the latter species in Dorset or on the Island. Mr. Wood's record of *Pecten cretosus* for the Salisbury area is clearly a mistake, as Dr. Blackmore states that he has never seen even a fragment from the horizon in question.

Spondylus spinosus would seem to be rare in this part of England, for we found none in Dorset, and only one example at Scratchell's Bay. It ranges throughout the White Chalk, including Norwich and Trimingham, the one exception being the *mucronata*-chalk of Salisbury.

Plicatula cf. *barroisi* was represented by a single example of small size from Scratchell's Bay. A similar small form, which we are unable to separate from this species, is found in great abundance at this horizon at Salisbury, and to a less extent in the *quadratus*-zone.

Lima granulata here reaches its maximum development, both in number and size, though it never attains the proportions of those found at Norwich and Trimingham. It ranges up from the zone of *Micraster cor-testudinarium*, but it is only in the *mucronata*-chalk that it assumes zonal importance. Dr. Blackmore does not find it below the *Micraster cor-anguinum*-zone at Salisbury, and Mr. Griffith does not record it in Hampshire.

Among the rarer lamellibranchs we found two broken examples of *Pteria* (*Avicula*) *cœrulescens* (Nilsson), which we have not hitherto recorded for the English coast, though we have found it in three other localities. The range as at present known is the *Uintacrinus*-band of Margate, the *quadratus*-chalk of Salisbury, and the *mucronata*-zone of Salisbury, Norwich, and Trimingham, This hitherto little-known species is admirably figured and described by Mr. Woods in his monograph on the "Cretaceous Lamellibranchia," Vol. ii, Part ii, p. 67, Pl. ix, figs. 13-16, 17a, b, 18, 19a, b.

Of the corals *Cœlosmilia laxa* is the dominant form, and it is often of large size, though it never reaches the dimensions of the magnificent examples of Norwich and Trimingham. It is found at the same horizon at Salisbury. We also collected *Parasmilia centralis* and *Axogaster cretacea*. *Stephanophyllia michelini*, which we found at Ballard Head, has no place in our list here, but it is is by no means rare at Norwich.

Cirripedes, usually so well represented in the zone, were exemplified by *Scalpellum maximum* alone. *Pyrgoma cretacea*, *Scalpellum fossula* and *Pollicipes fallax* were all collected in Dorset and at Norwich, but have not yet been found in the Isle of Wight.

Bryozoa are here strongly represented, and the chief forms which catch the eye are *Eschara acis*, *Semieschara arborea*, *Semieschara woodsi*, *Vincularia santonensis*, *Vincularia bella*, and *Porina filiformis*. All these forms, with the exception of *Eschara acis* and *Vincularia santonensis*, are, in the Island, mainly restricted to the zone under discussion. Unquestionably the most useful form in the field is *Porina filiformis*, which occurs in such profusion that we have found it in not a few of the barren quarries of the Chalk Ridge. Curiously enough, *Porina filograna*, which was so common and distinctive a form on the Dorset Coast, is comparatively rare here, though Mr. Brydone found it more abundantly than we did. The same remark, even in a greater degree, applies to the massive undetermined species of *Heteropora* which we alluded to as being common at Ballard Head and Studland Bay. All the other forms which we have mentioned are common at Scratchell's Bay, Alum Bay and Whitecliff, *Vincularia santonensis* and the two species of *Semieschara* being particularly abundant. *Eschara acis*, *E. galeata*, *E. lamarcki*, and *E. stigmatophora* (?) are all strongly represented.

We are indebted to Mr. Brydone for valuable assistance in identifying these beautiful forms.

In no other zone does *Serpula* assume so high a degree of importance. We have to go back to *Serpula avita* of the *Rynchonella cuvieri*-zone to find another Serpula restricted to one horizon. This most distinctive species is von Hagenow's *Serpula canteriata*, a smooth, obtusely pentangular form growing in the shape of an open whorl, after the fashion of *Crioceras*. The ornamentation figured by von Hagenow seems to be rarely preserved. This species is found at Norwich, Trimingham, and Salisbury. *Serpula turbinella* is larger and more abundant than in any other zone. Our lowest record for this species is a single example in the *Micraster cor-testudinarium*-zone, and it increases in size and number as we ascend the zone. *Serpula pusilla*, figured by Sowerby from the Norwich Chalk, is another new record, for we obtained three examples from Scratchell's Bay. The most difficult form to determine, however, is a free-growing Serpula with six or seven sharp angles and V-shaped markings on the flat inter-angular surfaces. In the Isle of Wight it is invariably heptagonal, while in Dorset it is almost as invariably hexagonal. We had the good fortune to find one perfect example at Scratchell's Bay which differs from all other species which we have found in that it has a base of attachment like a Parasmilia. The example in question is 33 mm. long and 4 mm. broad in the thickest part, bow-shaped, free of annular lines of growth, and with the angulations becoming more obtuse towards the rather contracted mouth. Whether the other examples were attached in the same way we know not, as they were all fragmentary. The only figure which is in any way suggestive of this form is that given by Goldfuss in the "Petrefacta" as *Serpula sexangularis*, Münster. The example figured is imperfect towards the base, so we cannot tell if it in that respect resembled our specimen. *Serpula fluctuata*, both here and at Salisbury, reaches a size and degree of ornamentation seen in no other zone, and is quite the handsomest of the larger Serpulæ found in the White Chalk. In this zone the flat spaces between the strong, wavy ridges are beautifully ornamented by horizontal markings, and this is a feature which we have seen at no other horizon.

Porosphæra here reaches an unexampled abundance, and all five species are well represented, *Porosphæra globularis* and *Porosphæra nuciformis* being the dominant forms. On the air-weathered fallen blocks at Scratchell's Bay one can collect them by the hundred. The flat, cushion-shaped variety of the former seems to be hardly so common as in Dorset, while in the case of the latter the largest and most strongly grooved forms come from the Island. *Porosphæra pileolus*, though fairly common, is notably smaller and rarer than in the zone immediately below.

As in Dorset, *Leptophragma murchisoni* and *Aphrocallistes* are the most characteristic sponges preserved in iron-oxide, the latter being from its restriction to this horizon a reliable guide-fossil in the field. *Ventriculites radiatus*, though abundant here, in no way rivals the size and abundance with which it occurs on the Norfolk coast, where it is quite a feature of the zone. The belemnites are often bored by *Cliona* and *Talpina*.

Vertebrate remains are represented by *Lamna appendiculata* and *Oxyrhina mantelli*.

In this zone we obtained our largest list, amounting to 105 species—a list which could be greatly extended by anyone who had more time at his disposal than we had in our brief visits to the sections.

CONCLUSION.

The only part of the English coast which we have excluded from our series is that which embraces the small and interrupted sections at Weybourn, Sherringham, Cromer and Trimingham on the Norfolk coast. It is only men like Mr. Clement Reid and Mr. R. M. Brydone* who, by devoting time to watch the ever-varying reef exposures, can hope to elucidate that problem, and Mr. Brydone has done it so ably and in such detail that we are content to leave the task in his hands. When we publish "The Inland Chalk of Norfolk" we shall include in that work such remarks on the coast as appear to us to be necessary.

With the completion of our survey of the Isle of Wight we bring to a close the series of papers entitled "The Zones of the White Chalk of the English Coast," a position which leaves us with mingled feeling of satisfaction and regret—of satisfaction that a work which by reason of its very length had become exacting and oppressive is at an end; and of regret that there is no longer the mystery of a Dorset, a Yorkshire, or even of an Isle of Wight to unravel. Indeed, a task of such magnitude should only have been essayed by one with abundant leisure. The brief holidays snatched from an over-busy professional life have, during the past twelve years, been given up unreservedly to this quest; and as not only all the field-work, but all the writing has had to be done in these vacations, away from library and museum, it would be little wonder if many mistakes had crept into the work, and that holidays as means of rest and recreation had failed in their object. Whatever the faults of this extended survey may be, either from insufficiency of time, care and experience, or from hasty deduction, certainly lack of material cannot be adduced as an excuse. During the past twenty years, while the work has been in the stages either of anticipation or active progress, we have collected considerably over 30,000 fossils from the White Chalk, to the end that the various genera and species could be studied as a vast zonal facies and not as isolated individuals. As, moreover, there is not one of these fossils which is not accurately zoned and localised, the collection will in the future be of high value to those who wish to study genera and species in bulk, unharassed by an uncertainty bred of the now traditional museum label bearing as its legend "Chalk: South of England."

Our work has evoked criticism and even condemnation by reason of the fact that we have not detailed cliff and quarry sections drawn to scale, and crowded with meaningless lithological detail, which is generally not the same in the next bay, or in a quarry a few hundred yards farther on. When this wealth of lithological detail is coupled with such illuminating zonal indications as *Micraster*, *Echinocorys*, *Inoceramus*, coral, and the like, we feel that such a course is more honoured in the breach than in the observance. In a word, these details, though dear to the heart of the arm-chair geologist, are, by reason of their ever changing nature, often actually misleading to the worker in the field.

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* R. M. Brydone, "The Stratigraphy and Fauna of the Trimingham Chalk," 8vo, London, 1900; *Geol. Mag.*, 1906, pp. 13 *et seq.*

However, whatever the limitation of the work may be, it is frankly zonal, and therefore zoological. The keynote to the whole series was given by the publication in 1899 of "An Analysis of the Genus *Micraster*,"* before the stratigraphical element was introduced. The desire has been to show that not only is the zonal theory correct, in that at certain indeterminate levels of the Chalk there exist fossils which are either rigidly restricted to each particular zone, or certain groups of guide-fossils which, though not so restricted, are by their association equally characteristic of horizon; but that certain fossils vary so markedly in shape and other essential features, as they range from a lower to a higher level, that we can assign these shape-variations with unerring certainty each to their particular zone. Another element of interest has been the attempt to trace the almost equally instructive variation in horizontal distribution, and as our area of observation has widened so has the fascination of the problem increased.

It is only in a deep-sea deposit like the Chalk, with slow, placid, and uninterrupted sedimentation taking place over vast periods of time, that we can reasonably hope to follow out every stage in the unbroken continuity of the evolution of a genus, or the equally interesting zonal variation of a species; and if "The White Chalk of the English Coast," has in any way brought forward new facts contributing to the study of the evolution of fossil forms, we feel that our labour will not have been in vain.

We know that it is only by amassing a vast zonal collection of the more important guide-fossils that we can attempt to educe any effective generalisation from the standpoint of evolution. To this end we have rigidly excluded from our collection every fossil, however perfect its condition, where the derivation was in the least degree uncertain. In our eyes a damaged fossil from a definite horizon is of more value than the fairest fossil from the "South of England." By collecting in this exclusive spirit we find that, not only do such groups as the echinids, belemnites, brachiopods, and lamellibranchs yield us results fertile in deduction, but that almost equally useful conclusions may be drawn from such unexpected sources as the bryozoa, corals, serpulæ and sponges. Indeed, there is hardly a group which, if handled in sufficient numbers, cannot be made to tell its own part in the great story of evolution in the times of the old Chalk Sea. The patient labour of men like Mr. S. S. Buckman and the late Mr. J. F. Walker is bearing its results, and as more observers are enlisted to work on the same lines, so will the broadness of our deductions be increased.

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* *Quart. Journ. Geol. Soc.*, vol. lv, p. 494.

The importance of this contention received its due recognition in the pronouncement of Dr. J. E. Marr, in his presidential address to the Geological Society in 1905, when he observed: "Turning now to mutations, where the varieties which succeed each other are closely related genetically, we have to consider the necessity for very careful study in distinguishing one mutation from another, as proved by recent work. In the early days of palæontological investigation, the characters utilised for the purpose of separating varieties were sufficiently obvious to be detected in single specimens, and the minute variations which have in some cases been found to mark off mutations from each other, were unknown. The researches of Mr. W. Bateson on the forms of *Cardium* in the Aralo-Caspian basin, and of Dr. A. W. Rowe on the variations of *Micraster* at different horizons, have proved the value of dealing with suites of specimens of each mutation, and subjecting them to minute and accurate measurement. It is obvious that much work of a similar nature remains to be accomplished in the case of other fossil forms; and those who follow Dr. Rowe's line of research will naturally undertake the study of forms which are preserved in sufficient numbers in the fossil state. This cannot be done by the examination of museum specimens; but specialists in the different groups of organisms must, as Dr. Rowe has done, obtain the specimens for themselves from the rocks in which they are entombed."*

The practical value of the advice given by Dr. Marr in the last sentence cannot be exaggerated. Our own views on this point were set forth in "An Analysis of the Genus *Micraster*," p. 497, in 1899, where we suggest that "if the rôle of the field-worker and the study-worker had been more frequently combined in the same individual we should have had fewer unreliable species." Suffice it to say that along the lines of rigid and extensive zonal collecting much of the future success in the study of evolution must be sought.

It now only remains to thank those who have assisted us so materially in the production of the present paper. It is a source of great satisfaction that these pages have once more been rendered beautiful and intelligible by Professor H. E. Armstrong's fine photographs. Baffling atmospheric conditions have necessitated many visits and the expenditure of much time and trouble, thereby making our debt of gratitude all the greater.

To Mr. Ernest Westlake is due all the credit for taking the measurements throughout the Island, as our task merely consisted in fixing the zonal junctions. The measurements occupied several weeks and were made with such scrupulous care that we unreservedly accept them as correct. It would be difficult to exaggerate our obligation to Mr. Westlake in this important particular, for not only were the measurements worked out by an experienced observer, but we were thereby freed to devote ourselves to the increase of our otherwise meagre lists.

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* *Quart. Journ. Geol. Soc.*, vol. lxi, p. lxxvi.

Dr. G. T. Prior has kindly contributed a note on the white siliceous nodules (see p. 289).

We are much indebted to Professor J. W. Gregory for his kindness in publishing a preliminary note on and diagnosis of the beautiful little bryozoon, which he has described in his forthcoming British Museum Catalogue of Bryozoa under the name of *Bicavea rotaformis*. This fossil is so abundant at its particular horizon in the Island and of such high zonal interest that we were particularly anxious to be able to quote it, and this, through Professor Gregory's kindness, we have now been enabled to do. A reference to this fossil will be found on p. 220 of this paper.

To Dr. F. A. Bather, Dr. H. P. Blackmore, Mr. R. M. Brydone, General C. F. Cockburn, Mr. G. C. Crick, Mr. G. E. Dibley, Mr. C. Griffith, Mr. Herries, Dr. F. L. Kitchin, Mr. W. D. Lang, Mr. W. K. Spencer, Mr. H. J. Osborne White and Mr. H. Woods we desire to express our gratitude for much help and information given in a manner so generous that the debt is but an added pleasure. One of the features of palæontological work in the present day is the ungrudging assistance given by workers in the same field, and it is only just to say that much of the palæontology in this paper would have been lacking in point and accuracy without the unselfish co-operation of the above-mentioned geologists. Nor would we forget the friendly interest in the work shown by those residing in the Island, for the help given by Professor John Milne of Shide, Dr. R. C. Brown of H.M. Prison, Parkhurst, and the late Dr. Joseph Groves of Carisbrooke will always be remembered with gratitude. By none was the publication of the paper awaited with keener anticipation than by Dr. Groves, and we can only deplore the all too early death which cut short the career of one whose mind was an inexhaustible storehouse of scientific fact and local lore.

But above all we would tender our heartful thanks to that best and most unselfish of friends, Charles Davies Sherborn, for his loyal and unremitting labour, not only in connection with the present paper but with the whole series. While not a little of the work on this coast series had been done before Mr. Sherborn joined us in the field, it had been done merely for the personal pleasure and satisfaction of working out a zoological problem, and it is only fair to say that, but for his friendly insistence and generous help, not a single word of the series would ever have been published. It falls to few to have so good a friend, and we take peculiar pleasure in giving expression to an obligation which is as profound as it is sincere.

It is only those who have critically examined the Chalk Ridge in the Isle of Wight who can adequately appreciate the difficulties encountered and surmounted in Mr. Sherborn's admirable maps which accompany this paper. We were told by those high in authority that we might possibly be able to zone the coast, but that in the Chalk Ridge we should find our Waterloo. The map is an answer to that challenge. It is certainly the most valuable part of the paper, as it shows the position of every zone at a glance, both in the quarries and on the coast. It is, indeed, a fitting termination to Mr. Sherborn's association with the "Zones of the White Chalk of the English Coast."

We have followed the course adopted in the other divisions of this series of papers in not including the Bryozoa and other microzoa in our tabular list of fossils at the end of this paper. It is not that we consider them as lacking in value in the field, for, indeed, the reverse is the case, but simply to preserve the uniformity of the series. Such of the microzoa as are of value in the field will be found to have received their due recognition in the text. For the same reason we have allowed certain fossils, the names of which we know to be incorrect, to remain unaltered in the present paper. As instances in point we would cite *Terebratulina gracilis* and the genus *Echinoconus.*

Finally, at the risk of unduly extending the scope of an already lengthy paper, we have included in our Zoological Summary much information concerning fossils in districts other than the Isle of Wight. We in no way regret this course, believing that it will enhance the usefulness of the paper in the eyes of those whose opportunity for extended field-work has not been so great as our own. In addition, we feel that in the final paper of this series a fitting occasion presents itself for giving a general summary of our information concerning the more important of the guide-fossils of the White Chalk.

We have been at some pains to compile a table of contents which shall be at the same time concise and illustrative of the chief geographical divisions described in the paper. By a judicious use of different type we believe that the more salient head-lines will at once catch the eye.

NOTES ON THE PLATES.

Plate VIII.—Compton Bay from the West. The range given is from the Wealden to the zone of *Micraster cor-testudinarium.* The latter zone can only be worked from fallen blocks.

Plate IX.—Eastern side of Freshwater Bay, showing the Arched Rock, the Stag Rock, and the truncated end of the old road which used to skirt the bay until the sea cut its way behind it. The range shown is from the zone of *Holaster planus* to that of *Actinocamax quadratus.*

Plate X.—Western side of Freshwater Bay, with High Down cliffs, showing Tennyson's Monument, Oldpepper Rock, New Ditch Point, Black Rock, and East High Down. The range in Freshwater Bay is from the zone of *Holaster planus* to that of *Micraster cor-anguinum*; while the High Down cliffs give a range from the zone of *Rhynchonella cuvieri* to the *Uintacrinus*-band.

PLATE XI.—EASTERN SIDE OF WATCOMBE BAY, giving a range from the zone of *Holaster planus* to that of *Micraster cor-anguinum*. This is the only accessible section of the *Micraster cor-testudinarium*-zone in the Island and it is excellently exposed.

PLATE XII.—THE EASTERN SIDE OF SCRATCHELL'S BAY, showing the Grand Arch, Sun Corner, and the palisade at top of the cliff. The crowding of the flint courses is well brought out in the surface above the grass slope. The zonal detail is given on Pl. XIV, but this picture gives a range from the zone of *Micraster cor-testudinariun* to that of *Actinocamax quadratus*, the fall in the foreground being in the latter zone The palisade at the top of the cliff coincides fairly closely with the base of the same zone.

PLATE XIII.—THE WESTERN SIDE OF SCRATCHELL'S BAY, WITH THE NEEDLES, giving a range from the *Marsupites*-band to the zone of *Belemnitella mucronata*. The Needles are cut in the chalk of the latter zone, which begins on the eastern edge of the great fall at the farther end of the bay. The fall in the foreground is in *quadratus*-chalk.

PLATE XIV.—GENERAL VIEW OF ALUM BAY AND SCRATCHELL'S BAY taken from a rock on the landward side of the third Needle. The Grand Arch, the two shoreward Needles, and the junction of the vertical *mucronata*-chalk with the vertical Tertiaries in Alum Bay are well shown. Note the manner in which the chalk in Alum Bay is cut along the bedding-planes. Range from zone of *Micraster cor-testudinarium* to the Tertiaries.

PLATE XV.—ALUM BAY, WITH ERODED VERTICAL *mucronata*-CHALK IN CONTACT WITH THE VERTICAL TERTIARIES. The contact with the plastic clay in the middle of the picture, the channelling of the clay by rain on the extreme right, and the clay "glacier" in the foreground are well brought out.

PLATE XVI.—ALUM BAY. DETAIL OF ERODED *mucronata*-CHALK AT THE JUNCTION WITH THE PLASTIC CLAY. The position of the chalk from which this picture was taken is shown on Pl. XV.

PLATE XVII.—THE SOUTHERN CLIFF OF THE CULVER FROM SANDOWN BAY, giving a range from the Greensand to the zone of *Micraster cor-anguinum*. The path to the shore is in the gap between the dark and light portions of the cliff. The white mass on the top of the cliff indicates the chalk heap from the foundations of the Marconigraph station, where we found plates of *Marsupites*.

PLATE XVIII.—GENERAL VIEW OF THE CULVER, showing the Eastern cliff and the Whitecliff proper, together with the White Horse, the belt of flintless chalk and the nodule-beds, and the fall in *mucronata*-chalk. It will be seen that the Whitecliff face is cut along the bedding-planes as in Alum Bay. The dark discolouration in the centre of the picture is due to the chalk being stained by a red *Protococcus* slime, caused by the constant dripping of water from face of the cliff. Range from the zone of *Micraster cor-anguinum* to the Tertiaries.

PLATE XIX.—POSITION OF THE BELT OF FLINTLESS CHALK AND OF THE NODULE-BEDS in the Eastern cliff of the Culver. The discolouration of the chalk is due to the red *Protococcus* slime. Range from the zone of *Micraster cor-anguinum* to that of *Actinocamax quadratus*. The nodule-beds are numbered from below upwards on the key-plate.

PLATE XX.—THE NOSTRILS, CULVER CLIFF, with part of the projecting cliff called the White Horse. The latter is in the zone of *Micraster cor-anguinum*, and the remainder of the cliff on the left in the zone of *Micraster cor-testudinarium*, the junction of the two zones being fixed at a strong tabular flint-band at the point where the White Horse joins the northern Nostril. In the roof of the southern Nostril is found the bed of *Membranipora* mentioned in the text.

PLATE XXI.—VIEW FROM EAST HIGH DOWN TO AFTON DOWN, showing the position of the Chalk Ridge, and its relationship to the White Chalk on the south and the Tertiaries on the north. Note the position of Pits No. 1 and No. 2 in *mucronata*-chalk and their relation to the *quadratus*-zone in Freshwater Bay. There is no spot in the whole island which so graphically illustrates the structure of the land. The picture also indicates the extremely feeble barrier which now exists between the inroads of the sea and the river Yar, which rises only a few yards from the beach. Once this barrier is breached, the Island is cut in two. The position of the old road in the eastern cliff of Freshwater Bay shows the encroachment of the sea in comparatively recent times.

PLATE XXII.—PIT NO. 37 ON THE SOUTH SIDE OF BRADING DOWN, showing the "black marl-band," the "spurious Chalk Rock," and the "*Bicavea*-bed." This is one of the few sections in the Island where these three features can be shown on the same plate. The ends of the measuring-rod rest on the two former features. The position of the remarkable white flints which occur in the lowest flint course in the *Holaster planus*-zone is also indicated. The "grey marl-band," which divides the zones of *Terebratulina gracilis* and *Holaster planus* occurs 7½ ft. above the "black marl-band." The remarkable siliceous nodules are not seen in this pit, as the section is not deep enough. The face photographed shows, therefore, only the two zones already mentioned; but the front of the pit displays the zones of *Holaster sub-globosus* and *Rhynchonella cuvieri.* This quarry gives a greater zonal range than any other in the Island, for the only others approaching it are at Pits 13, 51 and 77, and they do not embrace the Grey Chalk.

PLATE XXIII.—PIT NO. 77C, BRIGHSTONE DOWN, showing the "black marl-band" and the "spurious Chalk Rock." The "grey marl-band," 7½ ft. above the "black marl-band" divides the zones of *Terebratulina gracilis* and *Holaster planus*, and is situated at the top of the pit. Only these two zones are exposed here. We could not find the "*Bicavea*-bed" in this pit, as the chalk where it should occur was too obscured by vegetation.

NOTE ON THE MAPS OF THE ISLE OF WIGHT WHICH ACCOMPANY THIS PAPER, AND ON THE PHYSIOGRAPHY OF THE TERTIARY SEA-BOTTOM.

By C. DAVIES SHERBORN, Hon. F.Z.S.

During the nine weeks of 1904-1906 spent by Dr. Rowe and myself in examining the White Chalk of the Isle of Wight it became apparent that the preparation of a large scale map of the Chalk Ridge would not only be essential to the descriptive part of the paper but would be of more value to the student than a series of sections of different localities. And for this reason, that a 6-in. map enables one to show sufficient detail of coast section and quarries, particularly where, as in this island, the beds are more or less vertical.

To the unprofessional geologist like myself the plotting of the vertical beds on the east and west limbs of the Chalk area presented little difficulty, but the mapping of the Central area seemed formidable, especially as the time at my disposal was quite insufficient to allow of a minute and careful survey of the surface. I wish, therefore, to record here the assistance received from the mapping of the line of the so-called "Chalk Rock" in the map issued by the Geological Survey. After following that line over the Central area and satisfying myself as to its substantial accuracy I have used it as a base for the calculation of the zonal limits, which have themselves been defined from a careful examination of the various pits or road-cuttings now exposed. And I have the pleasure to thank my friend, Mr. Allen Howe, for his professional help and suggestion when drawing the zonal lines.

I have been told that it is not possible to show on the one inch to one mile map of the Geological Survey the zonal divisions of the Chalk. In my opinion this is nonsense. It is even worth pointing out that Barrois contrived fairly successfully to show the zones of the Chalk on a scale of five miles to one inch so long ago as 1876. These divisions made by Barrois thirty years ago might quite easily have been verified or corrected and added to our maps.

No one for a moment can state positively that the zonal lines on his map are indisputable, because no one better than the zoologist knows the impossibility of obtaining zoological junctions without openings from which to obtain his evidence. Such zonal lines, if preferred, can be put in by means of dots, although even that precaution has not seemed to me necessary after the short time spent in the examination of the Chalk of the Isle of Wight. The shifting of a zonal boundary line a few yards north or south or east or west by a subsequent observer is of far less import than the omission altogether of such lines from a geological map.

It has also been urged that such palæozoological knowledge as is needful for zonal purposes is only possible after years of study. This, also, is nonsense. With the exception of the microzoa, the Chalk contains scarcely 200 fossil species. Of these, less than fifty are useful as zonal guides, and it cannot be held that more than a week's study is needful to grasp the essential features of structure in so small a number of forms. The same remarks apply to any other formation beside the Chalk, so far as the percentage of fossils of value as zonal guides is concerned. The fact is that palæozoology has been neglected for years in this country, and the Geological Surveyor has not been encouraged, and often has not had the knowledge, to collect for himself the zoological evidence necessary for the proper interpretation of his field-work.

Equally nonsensical statements have been made as to the impossibility of zoning pits. We refuted them in the Yorkshire paper, they have been disproved by all the amateurs working on the Chalk of late years, and are finally exploded in this present paper. Naturally, it is dangerous to zone pits without a knowledge of the fauna, but, with that knowledge, half-an-hour should enable anyone to come to a fairly definite conclusion as to the position in the series of the beds he is investigating.

A point of especial interest brought out by the present survey is the evidence as to the physiography of the sea-bottom on which the lowest Tertiary beds in this area were deposited. Although it has been known for years that extensive denudation occurred in this country at the close of the Cretaceous period, it has not been possible till now to show a section of the Cretaceo-Tertiary junction of any length.[*] We are now able to show such a section twenty-one miles in length, and to show it with sufficient accuracy to draw the conclusion that in this particular area the later conditions seem to point to subaërial (and consequent washing) action rather than to a plain of marine denudation. The very striking thickness of *mucronata*-chalk left at intervals of the section seems to mark high downs, while the cuts into the *quadratus*-chalk may represent the remains of water-courses in the old landscape. As the chalk sank beneath the sea all superficial features would be stripped off.

This uneven surface of the bed of the Plastic Clay sea would, in its turn, naturally suggest that there may be something wrong with the mapped thickness of the Plastic Clay in this area. It is hardly conceivable that so uniform a thickness of clay as is shown on the Geological Survey map, could have been laid down on a sea-bottom which varied in depth in its own features, from 500 ft. to nothing, within a distance of two miles. We should possibly find that the Plastic Clay in the Isle of Wight showed a great variation in thickness, and it would be an interesting question for some geologist to take up. So long as the Chalk is unzoned such a source of error is quite possible, but directly the zonal age of the Chalk is determined, suspicion is aroused as to any uniform thickness of the lowest Tertiary deposit being possible on a surface showing hills of considerable height.

The measured thickness of Plastic Clay in the Isle of Wight is, so far as I have found it published :

	Feet.	
Alum Bay . .	84	Mem. Geol. Surv., Isle of Wight (Sheet 10), 1862, p. 34; do., do., 1889, p. 95.
Downend . .	110	
Ashey . . .	92	
Brading . .	140	
Whitecliff . .	163	

These are in themselves suggestive, but not extraordinary. A series of measurements from Alum Bay to Downend should prove of much interest.

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[*] Messrs. Treacher and White have made some valuable observations on this subject in the north of the London basin, in *Proc. Geol. Assoc.*, xix (9), 1906, p. 395.

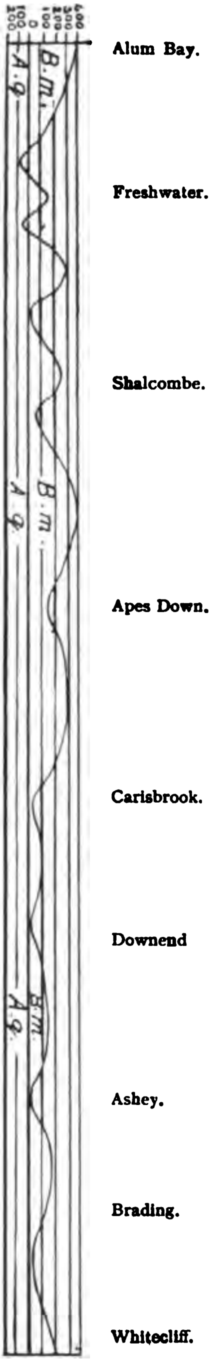

FIG. 26.—DIAGRAM TO SHOW SURFACE OF CHALK IN THE ISLE OF WIGHT AT THE COMMENCEMENT OF THE DEPOSITION OF THE EOCENE BEDS (PLASTIC CLAY).—*C. D. Sherborn.*

Taken from the North side of the Chalk Ridge, W. to E., between Alum Bay and Whitecliff Bay.

Horizontal scale 3 m. to 1 inch; vertical scale 100 feet to $\frac{1}{16}$ inch.

This Map of the Chalk Ridge of the Isle of Wight has been presented in eleven somewhat arbitrary sections on six sheets, as it seems more convenient for use in the field, and less likely to tear or otherwise damage than if the map were in one folded sheet. The eastern and western limbs of the Ridge are given on the scale of six inches to one mile, while the central area is given on that of two inches to one mile.

The Chalk of the southern area of the Island does not come within the scope of this paper, as it is mainly, if not entirely, confined to those beds below the White Chalk beds, with which this paper does not deal.

The Index provided to the four previous papers has been reprinted and completed so as to include references to this fifth paper, which completes our survey of the White Chalk of the English Coast.

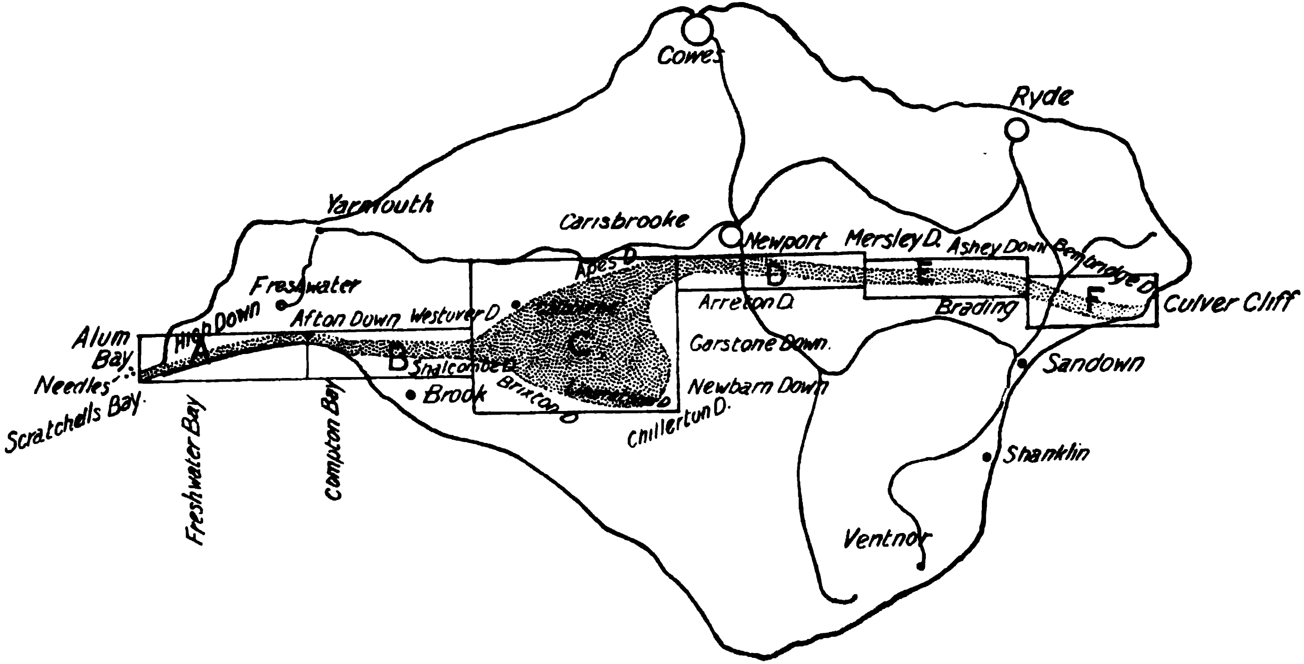

Fig. 27.—Outline Map of the Isle of Wight, Showing Areas Reproduced on the Large Scale Maps Accompanying this Paper.—*C. D. Sherborn.*

LIST OF FOSSILS FROM THE WHITE CHALK OF THE ISLE OF WIGHT.

ABBREVIATIONS.

B. m. = Zone of *Belemnitella mucronata.*
A. q. = Zone of *Actinocamax quadratus.*
M. t. = Zone of *Marsupites testudinarius.*
M. c.-a. = Zone of *Micraster cor-anguinum.*
M. c.-t. = Zone of *Micraster cor-testudinarium.*
H. p. = Zone of *Holaster planus.*
T. g. = Zone of *Terebratulina gracilis.*
R. c. = Zone of *Rhynchonella cuvieri.*

C. common; R.C. rather common; R. rare; R.R. rather rare.

	B. m.	*A. q.*	*M. t.*	*M. c.-a.*	*M. c.-t.*	*H. p.*	*T. g*	*R. c.*
Ventriculites radiatus, Mant.	C.	C.	C.	C.	C.	C.	R.	...
Ventriculites impressus, T. Smith	...	...	...	...	R.R.	R.C.	R.	...
Ventriculites decurrens, T. Smith	R.	R.R.	R.	...	...	...	R.	...
Ventriculites mammilaris, T. Smith	...	...	...	...	...	R.	R.	...
Ventriculites cribosus, Phill.	R.C.	...	...	...	...	...	...	...
Ventriculites infundibuliformis, S. Woodw.	...	...	...	R.	...	...	...	...
Plocoscyphia convoluta, T. Smith	C.	C.	C.	C.	C.	C.	C.	C.
Plocoscyphia labrosa, T. Smith.	...	...	...	...	...	...	R.C.	R.C.
Plocoscyphia cf. *fenestrata*, T. Smith	...	...	...	...	...	...	...	R.C.
Camerospongia aperta, Hinde	...	...	...	...	...	...	...	R.
Cephalites benettiæ, Mant.	...	...	...	...	...	...	R.	R.
Craticularia fittoni, Mant.	...	...	...	...	...	...	R.	R.
Coscinopora infundibuliformis, Goldf.	C.	R.C.	R.C.	C.	...	...	R.	...
Leptophragma murchisoni, Goldf.	R.C.	...	R.R.	R.	...	...	...	...
Guettardia stellata, Mich.	R.	...	R.R.	R.	...	R.R.	R.	R.
Aphrocallistes, sp.	R.C.	...	...	...	...	...	...	...
Placotrema cretaceum, Hinde	...	...	...	...	R.	...	...	...
Cliona cretacea, Portl.	C.	C.	C.	C.	C.	C.	C.	R.
Doryderma ramosum, Mant.	...	...	C.	C	...	...	...	...
Heterostinia obliqua, Benett	...	R.C.	R.R.	R R.	R.R.	R.	...	...
Siphonia königi, Mant.	R.	R.	R.R.	R.R.	...	...	...	...
Plinthosella compacta, Hinde	...	...	...	C.	...	...	...	...
Plinthosella squamosa, Zittel	...	...	...	R R.	...	...	...	...
Pharetrospongia strahani, Sollas	R.R.	R.C.	R.	R.R	R.	R.	...	R.
Porosphæra globularis, Phill.	C	C.	C.	C.	C.	C.	C	R.R.
Porosphæra nuciformis, von Hag.	C.	R.R.	R.R.	R.C.	...	...	...	...
Porosphæra pileolus, Phill.	C	R R.	R.R	R.C	R.	R.	...	...
Porosphæra patelliformis, Hinde	C.	R.R	R.R.	R.R.	R.C.	R.R.	R.	...
Porosphæra arrecta, Hinde	R.R.	R.	R.	R.	...	...	...	...
Talpina sp., von Hag.	C.	...	...	...	...	...	...	...
Spinopora dixoni, Lonsd.	R.C.	...	R R.	R.	...	...	R.	R.
Cœlosmilia laxa, E. and H.	C.	R.C.	...	...	...	...	...	...
Parasmilia centralis, Mant.	R.C.	...	R.R.	R.	R.R.	R.C.	R.C.	R.R.
Parasmilia granulata, Dunc.	...	...	...	...	R.	...	...	...
Caryophyllia cylindracea, Rss.	...	...	R.	...	...	...	...	...
Onchotrochus serpentinus, Dunc.	...	...	...	...	...	R.	R.C.	R.R.
Stephanophyllia bowerbanki, E. and H.	...	...	...	...	...	...	R.	...
Micrabacia coronula, Goldf.	...	...	...	...	...	...	R.	...
Axogaster cretacea, Lonsd.	R.R.	...	...	...	...	...	R.	R.

	B.m.	*A. q.*	*M. t.*	*M. c.-a.*	*M. c.-t.*	*H. p.*	*T. g.*	*R. c.*
Serpula plana S. Woodw.	C.	C.	C.	C.	C.	C.	R.	R.
Serpula pusilla, Sby.	R.R.	...	...	...	...	...	...	...
Serpula granulata, Sby.	R.	R.	...	...	R.R.	R.	R.	R.
Serpula ampullacea, Sby.	R.C.	R.C.	R.R.	R.C.	R.R.	R.R.	R.C.	...
Serpula canteriata, v. Hag.	R.C.	...	...	...	...	...	...	...
Serpula sp. (heptagonal)	C.	...	...	...	...	...	...	...
Serpula pentangulata, S. Woodw.	...	...	...	...	...	R.	...	...
Serpula fluctuata, Sby.	R.	...	...	R.R.	...	R.	...	...
Serpula cincta, Goldf.	...	...	...	...	C.	R.R.	...	...
Serpula macropus, Sby.	R.	...	...	...	...	...	...	R.
Serpula avita, Sby.	...	...	...	...	...	...	...	C.
Serpula turbinella, Sby.	C.	C.	R.R.	R.R.	...	...	...	...
Serpula ilium, Goldf.	C.	C.	R.C.	C.	C.	C.	C.	...
Serpula plexus, Sby.	...	...	R.	...	...	...	...	...
Serpula gordialis var. *serpentinus*, Schlot.	...	R.R.	...	R.	R.R.	...	...	...
Serpula sp: (adnate: long smooth tube)	R.	...	...	R.	R.	R.	...	...
Scalpellum maximum, Sby.	R.	...	R.	...	...	R.	R.	...
Pollicipes glaber, Roem.	...	...	...	...	...	R.	...	...
Echinocorys scutatus, Leske	C.	C.	R.C.	R.C.	R.C.	R.C.	...	...
Echinoconus conicus. Ag.	R.	...	...	R.	...	R.	...	...
Echinoconus vulgaris, Lam.	...	...	R.R.	R.C.	...	...	...	...
Echinoconus albo-galerus, Lam.	...	...	...	R.	...	...	...	...
Echinoconus globulus, Desor	...	...	R.	...	...	...	...	...
Echinoconus subrotundus, Ag.	...	...	...	...	...	...	R.R.	R.
Discoidea dixoni, Forbes	...	...	...	...	...	R.	R.	C.
Cardiaster pillula, Lam.	R.R.	R.R.	...	...	...	...	...	...
Cardiaster pygmaeus, Forbes	...	...	...	...	...	...	...	R.
Cardiaster cretaceus, Sorig.	...	...	...	...	...	...	...	R.
Cardiaster ananchytis, Leske	R.	...	...	...	...	...	...	...
Holaster planus, Mant.	...	...	...	...	...	C.	C.	...
Holaster placenta, Ag.	...	...	...	R.	R.R.	R.R.	...	...
Infulaster rostratus, Forbes	...	...	R.	R.	...	...	...	...
Hemiaster minimus, Ag.	...	...	...	R.	R.	R.	R.C.	R.C.
Micraster cor-anguinum, Leske	R.	R.	R.R.	R.C.	...	...	...	...
Micraster cor-anguinum var. *latior*, Rowe	...	...	...	R.R.	...	...	...	...
Micraster praecursor, Rowe	...	...	...	R.	R.C.	C.	...	...
Micraster cor-testudinarium, Goldf.	...	...	...	...	C.	R.	...	...
Micraster leskei, Desm.	...	...	...	...	...	R.R.	...	...
Micraster cor-bovis, Forbes	...	...	...	...	...	R.R.	R.R.	...
Epiaster gibbus, Lam.	...	...	...	R.	...	...	...	...
Cidaris hirudo, Sorig.	C.	C.	R.R.	C.	C,	C.	C.	C.
Cidaris sceptrifera, Mant.	...	...	R.	C.	R.C.	R.C.	...	...
Cidaris perornata. Forbes	...	...	...	R.C.	R.	R.	...	...
Cidaris clavigera, König	...	...	R.	R.C.	R.C.	R.C.	R.R.	R.
Cidaris subvesiculosa, d'Orb.	R.C.	...	...	R.R.	...	...	R.	...
Cidaris serrifera, Forbes	...	...	...	...	C.	C.	R.C.	R.
Cidaris serrata, Desor	C.	...	...	...	...	...	...	...
Cidaris pleracantha, Ag.	R.R.	...	...	...	...	...	...	...
Salenia granulosa, Forbes	R.	...	...	...	R.	R.R.	...	R.R.
Salenia geometrica, Ag.	R.	...	...	...	...	...	...	...
Cyphosoma königi, Mant.	R.	...	R.	R.R.	...	...	...	...
Cyphosoma corollare, Klein	R.	...	...	R.	...	...	...	...
Cyphosoma spatuliferum, Forbes	...	...	...	...	...	R.	...	...
Cyphosoma radiatum, Sorig.	...	...	...	...	R.C.	C.	C.	R.

	B. m.	*A. q.*	*M. t.*	*M. c.-a.*	*M. c.-t.*	*H. p.*	*T. g.*	*R. c.*
Ophiura serrata, Roem.	...	...	...	...	...	R.	..	...
Marsupites testudinarius, Miller	...	...	C.	...	...	...	...	...
Uintacrinus	...	...	C.	...	...	...	...	...
Bourgueticrinus ellipticus, Miller	C.	C.	C.	C.	C.	C.	C.	R.C.
Pentacrinus agassizi, v. Hag.	...	...	...	...	R	C.	C.	R.
Metopaster parkinsoni, Forbes	C.	...	...	...	...	R.	...	...
Metopaster mantelli, Forbes	R.C.	...	R.	...	...	...	R.	R.
Metopaster uncatus, Forbes	R.	...	...	...	...	...	...	...
Mitraster hunteri, Forbes	C.	...	...	...	R.	...	R.	R.
Mitraster rugatus, Forbes	R.R.	...	...	...	...	...	...	...
Pentaceros pistilliferus, Forbes	...	...	...	R.	...	...	...	...
Pentaceros ocellatus, Forbes	...	...	...	R.	...	...	...	R.
Pentaceros bulbiferus, Forbes	R.	...	R.	...	...	...	R.	R.
Pentaceros boysi, Forbes	...	...	...	R.	...	...	...	R
Pentagonaster megaloplax, Sladen	...	R.R.	R.R.	R.	R.	R.	R.	R.C.
Pycnaster angustatus, Forbes	C.	R.	...	...	...	R.	...	...
Rhynchonella limbata, Schloth.	C.	R.C.	...	...	...	R.	...	...
Rhynchonella plicatilis, Sby.	R.C.	R.C.	R.	...	...	R.	...	...
Rhynchonella reedensis, Eth.	R.C.	R.C.	R.R.	R.C.	R.C.	R.C.	R.R	...
Rhynchonella cuvieri, d'Orb.	...	...	...	...	...	R.C.	R.C	C.
Magas pumilus. Sby.	R.C.	...	...	...	...	...	...	...
Thecideum wetherelli, Morris	R.C.	R.C	R.C.	C.	...	...	...	...
Thecideum cf. *vermiculare*, Schloth.	R.	...	...	...	...	...	...	...
Crania parisiensis, Defr.	...	...	R.	R.C.	...	...	...	...
Crania egnabergensis, Retz.	R.	R.R.	R.R.	R.R	R C.	R.R.	R.	...
Crania costata G. B. Sby.	R.C.	...	...	...	...	...	...	...
Terebratula carnea, Sby.	R.C.	...	...	...	R.C.	R C.	C.	R.R.
Terebratula semiglobosa, Sby.	...	...	...	C.	R.C.	R.C.	C.	R.R.
Terebratulina striata, Wahlen.	R.C.	R.R.	R.R.	R.C.	R.R.	R.R.	R.R	R.
Terebratulina rowei, Kitchin	...	R.	R.R.	...	...	...	...	...
Terebratulina gracilis var. *lata*, Eth.	...	...	...	...	...	R.C.	C.	R.R.
Kingena lima, Defr.	R.R.	...	R.	R.R.	...	...	...	...
Inoceramus cuvieri, Sby.	...	C.	C.	C	C.	R.	C.	...
Inoceramus sp.	C.	...	...	...	...	...	...	...
Inoceramus sp.*	...	...	...	...	...	R.	...	...
Inoceramus lamarcki, Park.	...	R.C.	...	R.	C.	R.C.	R.C	R.R.
Inoceramus brongniarti, Sby.	...	...	...	...	...	R.R.	R.C.	R.
Inoceramus mytiloides, Schlot.	...	...	...	...	...	...	...	C.
Plicatula sigillina Woodw.	C.	R.C	R.C.	C.	C.	R.C.	R.R.	...
Plicatula barroisi, Peron	R.	...	...	R.	R.R.	R.	R.	...
Ostrea vesicularis, Lam.	C.	C.	C.	C.	C.	C.	R.C	R.R.
Ostrea lateralis, Nilss.	R.R.	R.R.	...	R.	...	R.	R.	...
Ostrea hippopodium, Nilss.	R.C	...	...	...	C.	R.R.	R.C	R.
Ostrea semipiana, Sby.	...	R.R.	...	...	R.	R.R.	R.R.	...
Ostrea normaniana, d'Orb.	...	...	R.	...	...	...	...	...
Ostrea wegmanniana, d'Orb.	...	...	R.C.	R.	...	R.	...	...
Ostrea acutirostris, Nilss.	R.	...	...	...	...	...	...	...
Spondylus spinosus, Sby.	R.	R.R.	R.R.	R.R.	C.	C.	C.	...
Spondylus latus, Sby.	C.	C.	C.	C.	C.	R.C.	R.C	R.
Spondylus dutempleanus, d'Orb.	R.R.	...	...	R.	...	R.	R.	R.
Lima granulata, Nilss.	R.	...	...	...	...	...	...	...

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* H. Woods, "Mollusca of Chalk Rock," *Quart. Journ. Geol Soc.* Vol. liii, 1897, Pl. xxvii, Figs. 4, 15.

	B. m.	*A. q.*	*M. t.*	*M. c.-a.*	*M. c.-t.*	*H. p.*	*T. g.*	*R. c.*
Lima cretacea, Woods	...	...	...	...	...	...	R.	...
Lima decussata, Goldf.	R.	...	R.	...	...	R.R.	R.R	...
Lima wintonensis, Woods	...	...	...	...	...	R.	...	...
Lima hoperi, Mant.	...	...	R.	...	R.	R.	R.	...
Pecten quinque-costatus, Sby.	R.C.	R.C.	R.R.	...	...	R.	R.	...
Pecten cretosus, Defr.	R.C.	R.R.	R.	R.C.	R.	R.	R.	...
Pecten campaniensis, d'Orb.	R.R.	...	...	...	...	...	...	...
Pecten pexatus, Woods	...	...	...	...	...	R.	R.	...
Pteria (*Avicula*) *cærulescens*, Nilss.	R	...	...	...	...	...	...	...
Septifer lineatus, Sby.	...	R.	...	...	...	...	...	...
Teredo amphisbæna, Goldf.	...	...	...	...	...	R.	R.	R.
Radiolites mortoni, Mant.	...	...	...	...	...	...	R.	...
Aporrhais sp.	...	...	...	...	...	R.	R.	...
Pleurotomaria perspectiva, Mant.	...	...	...	...	R.	...	R.	...
Belemnitella mucronata, Schlot.	R.C.	...	...	...	...	...	...	...
Actinocamax quadratus, Blainv.	...	R.	...	...	...	...	...	...
Actinocamax granulatus, Blainv.	...	R.	...	...	...	...	...	...
Nautilus cf. *atlas*, Whiteaves	...	...	...	...	...	...	R.	R.
Ammonites peramplus, Mant.	...	...	...	...	...	...	R.	...
Aptychus portlocki, Sharpe	R.	...	...	R.	...	...	...	...
Oxyrhina mantelli, Ag.	R.	...	...	...	R.	...	R.	...
Lamna appendiculata, Ag.	R.	...	...	R.	R.	R.	R.	...
Ptychodus mammillaris, Ag.	...	...	...	...	...	R.	...	R.

AN INDEX

TO

"THE ZONES OF THE WHITE CHALK OF THE ENGLISH COAST."

("PROC. GEOL. ASSOC., XVI (6), 1900; XVII (1), 1901; XVIII (1), 1903; XVIII (4), 1904; XX (4), 1908.)

By C. DAVIES SHERBORN.

IN these contributions to our knowledge of the White Chalk many observations are scattered throughout the text, which it seems desirable to bring together by means of an index.

The history of a fossil species will be best understood by taking the references backwards, as much new information from each area has been collected and presented in part V for the first time.

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OF THE

Geologists' Association.

EDITED BY

HORACE WOOLLASTON MONCKTON.

(*Authors alone are responsible for the statements in their respective Papers.*)

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The Association will visit the Paris Basin at Easter under the direction of Prof. Dollfus and others, and the following pamphlet will be of great value to those taking part in the Excursion.

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By GEO. F. HARRIS, F.G.S., and H. W. BURROWS, A.R.I.B.A.

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THE CENTENARY OF THE GEOLOGICAL SOCIETY.

By R. S. HERRIES, M.A., F.G.S.

(Presidential Address delivered February 7th, 1908).

THE time has now come round when, in accordance with the usual custom, I have to address you at the end of my period of office. The past year has been an uneventful one for us, though it has seen the completion of the transfer of the Library to University College, which was sanctioned last year, and the beginning of the fiftieth year of our existence. Death has taken its usual toll of our members, and among those we have lost are two veteran geologists of distinction, Sir James Hector and Mr. J. F. Walker, but fortunately we have not to deplore, as we had last year, the loss of any of those who have been intimately connected with the management of the affairs of the Association.

One event, however, has happened during the year which has caused considerable stir in the geological world, and has been a landmark in the history of geological science. I mean the celebration of the Centenary of the Geological Society, and I propose to make it the subject of my address this evening.

The state of geology at the time of the foundation of the Society formed the subject of the admirable address delivered by the President, Sir Archibald Geikie, at the time of the celebration, and so only requires a very brief reference from me.

When the Geological Society was founded a hundred years ago, the science of geology as we know it can scarcely be said to have existed. The name, indeed, was first used in 1778 (the year, curiously enough, in which Greenough was born), but its own inventor, De Luc, in 1809, remarked that the science "was termed geology before it was entitled to the name." Problems, more or less connected with geology, had for many years exercised the minds of individuals, and the views of these writers are admirably summarised in the opening chapters of "Lyell's Principles." Towards the end of the eighteenth century these views were taking a more definite shape, and a much large number of persons were interesting themselves in the history of the earth, attracted by the teaching of Werner in Saxony, and Hutton in Scotland; but their energies were largely wasted in speculative disputes as to whether the sea or the earth's internal fires had the greater effect on the origin of rocks and the evolution of the present form of the earth, and hence they were dubbed Neptunists and Vulcanists respectively. Such was the jealousy between the rival parties that Jameson, a fervent disciple of Werner (" System of Mineralogy," vol. i, p. xx), says in a footnote to his definition of " Géognosie ": " By geology, Werner understands idle and imaginary speculation respecting the formation of the earth" ; while Bakewell, who was more or less independent, in his " Introduction to Geology," says that geognosy and geology are synonymous, but adds, in a footnote, that " the term 'well-educated geognost,' as used by some writers, denotes a perfect disciple of Werner who has lost the use of his own eyes by constantly looking through the eyes of his master."

It is difficult for us to imagine that a hundred years ago all that language of geology, which comes so easily to its present-day students, though it sounds such gibberish to the casual visitor to one of our excursions, was practically non-existent—but so it was. Such terms as Cambrian and Silurian, dip and strike, anticline and syncline, unconformity and denudation, were unknown, except possibly to the miner, from whom some of them were borrowed. The study of fossils was just beginning, though it could hardly be called palæontology in the sense that we understand it. Petrology was, of course, not known till many years afterwards, but mineralogy attracted many students and had made considerable advances. What most of us would now consider the principal branch of geological science—namely, stratigraphical geology—was undreamt of by the teachers of those days; but there was in this country a man who, as the result of his practical observations, had already come to the conclusion that certain strata could be known by their fossil contents, and that these strata always have a definite relation to each other in order of super-position, and he had coloured geologically, as early as 1799, the map of the country round Bath. This was the germ of stratigraphical geology which gave the key to the life-history of the earth, and the discoverer was William Smith, who was rightly called by Sedgwick, in 1831, when presenting him with the first Wollaston Medal, the " Father of English Geology." William Smith, it may be noted, was, like another geological leader, Cuvier, born in the year 1769, that *annus mirabilis* which saw the birth of so many great men, to name only Napoleon and Wellington. He was never a member of the Geological Society, and his work was for some time not much noticed; but in the end he had full acknowledgment, and worthily heads that list of great geologists, the recipients of the Wollaston Medal.

FOUNDATION, CONSTITUTION, AND EARLY HISTORY OF THE SOCIETY.

Such was the state of affairs when on November 13th, 1807, a company of eleven gentlemen, two others who had been asked having been unable to join, met together at dinner at the Freemasons' Tavern and founded the Geological Society, and constituted themselves and the two absentees the first members. If there is anything in superstition, there never was a society which began under more unlucky auspices. Founded by thirteen people on the thirteenth day of the month, the Society had also its birthday on the most unlucky of all days, a Friday! The subsequent history of the Society and its flourishing condition to-day has shown that in this instance the prophets of evil, if any there were, were at fault. Possibly the absence of two of the thirteen saved the situation. The infant Society was, however, nearly strangled in its cradle soon after the completion of its first year by the endeavour of the Royal Society to bring it into tutelage. Had it not then been for the determined action of Greenough and others it can hardly be doubted that the unlucky star would have been in the ascendant, and the Society would have died of inanition.

The names of those present at this memorable dinner were: Arthur Aikin, William Allen, Dr. William Babington, James Louis Count de Bournon, Humphry Davy, Dr. James Franck, George Bellas Greenough, Richard Knight, Dr. James Laird, James Parkinson, and Richard Phillips. The two others were William Hasledine Pepys and William Phillips. Of these only three can be said to have made either then or subsequently their mark in geology, namely, Greenough, Parkinson, and William Phillips, though Aikin wrote a manuscript account of the structure of Shropshire, to which Murchison acknowledged his indebtedness. He was, however, more of a chemist, as were Allen, Pepys and Richard Phillips. Babington, Franck, Laird and Parkinson belonged to the medical profession. Count de Bournon, a French *émigré*, was a distinguished mineralogist, and Aikin, Laird and Babington had also paid considerable attention to that subject. Knight had experimented on the result of fusion of rocks, and last, but not least, Sir Humphry Davy, as he afterwards became, was the well-known chemist and philosopher, who was at the time Secretary, and afterwards filled the chair, of the Royal Society. A fuller account of the Founders may be read in Mr. H. B. Woodward's "History of the Geological Society of London," and I may take this opportunity of expressing my indebtedness to the author for many of the facts contained in this address.

The objects of the Society were declared to be "for the purpose of making geologists acquainted with each other, of stimulating their zeal, of inducing them to adopt one nomenclature, of facilitating the communication of new facts, and of ascertaining what is known in their science, and what yet remains to be discovered." The idea of the Society was to be a monthly dining club, meeting at the Freemasons' Tavern, but the numbers soon grew too large for it to be continued in this way, and after permanent rooms had been engaged, the monthly dinners were gradually dropped. Short regulations were framed dealing with the method of election, introduction of visitors, subscriptions, and communications.

At this first meeting Greenough was appointed Treasurer, and Dr. Laird, Secretary. Nothing is said about a President, but the minute recording these facts is signed by Greenough, thus showing that he acted as Chairman from the first.

At the second meeting, on December 4th, 1807, it was decided to have a Patron and a President. The Right Hon. Charles Francis Greville, who had formed a fine collection of minerals, was chosen for the former post, and Greenough for the latter, his place as Treasurer being filled by the selection of Pepys. Forty-two Honorary Members were elected, and a committee was appointed to draw up a code of rules. At this meeting the first two communications were made to the Society in the form of exhibits by Mr. Knight and Count de Bournon.

At the next meeting, on January 1st, 1808, the Rules proposed by the committee were adopted. The declared object of the Society differs somewhat from that enunciated at the first meeting, the concluding words, "and of ascertaining what is known in their science, and what yet remains to be discovered," being altered to "and of contributing to the advancement of Geological Science, more particularly as connected with the Mineral History of the British Isles," an alteration which can scarcely be said to be an improvement, though in subsequent issues of the Rules this last paragraph alone appears as the object of the Society's institution. The Society was to consist of a Patron, a President, two Vice-Presidents, a Treasurer, a Secretary, Ordinary and Honorary Members. The officers, except the Patron, were to be elected annually by ballot. Then follow regulations dealing with the election of members, conduct of business at meetings, subscriptions, and visitors. A committee composed of the officers and three members, chosen by ballot, was to be appointed annually to act as Trustees of all presents given to the Society, and all communications were to be approved by this committee previous to their being read before the Society. In this provision we see the beginning of the Referee system, which has often been the subject of criticism among authors of papers and the Fellows of the Society generally. The two Vice-Presidents appointed were Davy and Dr. Babington, and the three first elected members of the committee, which was known as the Committee of Trustees, were Aikin, Allen, and Richard Phillips. In 1809 their number was increased to five. At this meeting the first two papers were read before the Society by John Taylor, an Honorary Member, and W. H. Pepys. It was further memorable for the foundation of the Society's Museum, by an offer of Dr. Babington to present a cabinet for the reception of specimens, which soon began to accumulate.

From that time the Society began to increase in numbers, for, during 1808, 36 Ordinary Members and 44 Honorary Members were elected. These, added to the 13 Original Members, the Patron, and the first batch of 42 Honorary Members, brought the numbers up to 136. It is not surprising that before the end of the year the Society decided to engage its own rooms, and in March, 1809, these were found at No. 4, Garden Court, Temple.

Among the earliest members elected was Sir Joseph Banks, the President of the Royal Society, but he resigned early in 1809, alleging that the Society "had deviated from the principles which they had entertained at their first establishment." How they had done so is not clear, but probably Banks was alarmed at the growing popularity of the Society and their independence of action in deciding to have a home of their own. Following on this resignation, a "Plan for consolidating the Geological with the Royal Society as an Assistant Society" was proposed by Charles Greville, the Patron. Put shortly, the plan was that the Society should consist of two classes of subscribing members, the first class being those who were Fellows of the Royal Society, who would form the Council, the remainder making up the other class, to be known as Assistant Members. The Council was to conduct all the affairs of the Society, to elect members, and make bye-laws; but, while the President was to be elected from the first class, the other officers could be chosen from the members at large. All papers relative to geology or mineralogy were to be communicated to the Council of the Royal Society, who were to select such papers as they pleased for reading before that Society, and for printing in the "Philosophical Transactions," while the Geological Society might keep any papers not required by the Royal Society, and publish them if they thought fit, at their own expense.

It is difficult to believe that the promoters of this plan seriously expected the Society to adopt it, and thereby commit the "happy despatch," for, as I have already said, they must have died of inanition in a few years had they done so. But there is no doubt that considerable pressure was brought to bear, and it must be remembered that about half the members were Fellows of the Royal Society, who might have thought that they ought to support a proposition brought forward with all the prestige of the senior Society. Good sense, however, prevailed, and the proposals were rejected at a special meeting, at which twenty were present, including eight of the original members. Only four of those present seem to have been Fellows of the Royal Society, so possibly many of those stayed away, so as to give the others the opportunity of voting on what principally concerned their interests. The credit of bringing about this result, and practically saving the Society, was largely due to the firmness and tact of Greenough, to whom the Society was thus deeply indebted, a fact which was always recognised during his life, and recalled at the time of his death by Hamilton, the President, in reading his obituary notice. The immediate result of the rejection of the plan was the resignation of Greville and Davy, and from that time the Society did without a Patron. Davy rejoined in 1815, by which time no doubt the wisdom of the Society's action was generally recognised. Mr. H. B. Woodward, in his History, has quoted some remarks of Sir William Huggins, when President of the Royal Society in 1903, in which he says that "the scientific world have good reason to rejoice over the wise and far-seeing policy" of those who decided to keep the young Society free from obligations to any other body. In the Address* which I had the honour to present to the Society in your name at the celebrations last September, this incident was recalled, not as in any way reflecting on the action of the Royal Society, but to illustrate the consistent course of conduct of the Geological Society, who, having freed themselves, never placed any obstacle in the way of the formation of other bodies, such as our own Association and many local societies, whose aim was the study of geology. That their interests have not suffered thereby is certain; on the contrary, they have found in the daughter societies excellent recruiting ground, and a means has been provided of recording many geological observations which, while of considerable local interest, are not of such general importance as to warrant their publication in the Journal of the Geological Society.

Having got safely over these early troubles, the Society went on prospering, and never looked back. About this time they began the formation of a Library, and early in the next year, 1810, they had outgrown their premises in the Temple, and joined with the Medical and Chirurgical Society in taking No. 3, Lincoln's Inn Fields. In the same year permanent Trustees were appointed, and the Committee of Trustees who had up till now managed the affairs of the Society was replaced by a Council consisting of twenty-one members, of whom Greenough was still President. Sir John St. Aubyn, Dr. Babington, Robert Ferguson, and Sir Abraham Hume were Vice-Presidents; Dr. Laird and Leonard Horner, Secretaries; Pepys, Treasurer; and Count de Bournon, Foreign Secretary. In 1811, at the instance of Greenough, a resolution was passed limiting the term of office of President to two years, and this rule has been always adhered to, though, as I pointed out in my address last year, the terms of the subsequent Charter made the passing of a bye-law to that effect *ultra vires*.† In accordance with this resolution, Greenough, after serving two more full years, resigned the Presidency in 1813, after having held it for five years and three months from the foundation of the Society. He was in subsequent years twice re-elected to the office. After 1810 no more Honorary Members were elected, and from 1814 onwards they were replaced by Foreign Members.

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* See foot p. 376.

† *Proc. Geol. Assoc.*, vol. xx, p. 21.

The year 1811 saw the issue of the first of the Society's publications, Vol I. of the *Transactions*, while in 1812 the first of a long series of able permanent officials was appointed in the person of Thomas Webster, who was made Keeper of the Museum and Draughtsman.* The Library and Museum continued to grow, and in 1816 another move was made to No. 20, Bedford Street, Strand. In 1820 Greenough's Map was published. He had been at work on it since 1808.

We now come to a most important event in the history of the Society, by which its constitution was, as it were, crystallised. I mean its incorporation by Royal Charter. The date of the Charter is April 23rd, 1825, and the Society was incorporated under the name of "The Geological Society of London," instead of "The Geological Society," under which title it was founded. The declared object of the Society is simply "for investigating the Mineral structure of the Earth," and it is stated that considerable sums of money have been expended "in the purchase and collection of books, maps, specimens and other objects and in the publication of various works." Two classes are mentioned, Fellows and Foreign Members, the number of Fellows being indefinite. The first Fellows are declared to be the Rev. William Buckland, Arthur Aikin, Dr. John Bostock, George Bellas Greenough, and Henry Warburton. Of these Buckland was the elected President for the year, Dr. Bostock was his successor in office, Aikin and Greenough were Founders, and Warburton, who was elected in 1808, had been largely instrumental in securing the grant of the Charter. They are directed to appoint before the next annual meeting in February such other persons to be Fellows and Foreign Members as they think fit, and they are until that time appointed to be the first Council, Buckland being President. At the Annual Meeting one-fifth or more of the Council must be removed by a ballot of the Fellows, and others elected so as to bring the Council up to twenty-three. From among the Council thus constituted the Fellows are to elect by ballot a President, and as many Vice-Presidents, Secretaries, and Treasurers as they shall think proper. From and after the first annual meeting the Fellows are empowered to elect or remove Fellows and Foreign Members by ballot at general meetings, to appoint officers and servants, and to make such orders and bye-laws as shall appear useful for the government of the Society, and for settling certain specified matters, with power to alter, suspend, or repeal such orders and bye-laws, with a proviso that they must not be repugnant to the Charter or the laws of the Realm.

In accordance with the directions contained in the Charter the Council of five proceeded to appoint as additional Fellows practically all the existing members to the number of 367, and as there was no provision in the Charter for Honorary Members, they gave them the choice of becoming Fellows in the ordinary way, but without ballot. Only six availed themselves of this offer; the remainder, numbering upwards of fifty, were allowed to remain on the list with the same privileges as Foreign Members. At the next annual meeting the full Council of twenty-three was elected, and in 1827 the first set of Bye-Laws was adopted, not differing materially from those now in force, though they have naturally been amended in detail from time to time to suit altered ideas and requirements. The number of Foreign Members was by the first Bye-Laws declared to be unlimited, though it is not so stated in the Charter, and in 1863 it was fixed at forty. In the Bye-Laws one of the secretaries is designated as the Foreign Secretary, and the practice since the granting of the Charter has been to have two ordinary Secretaries, one Foreign Secretary, one Treasurer, and four Vice-Presidents, except in 1826, when there were three ordinary Secretaries, and in 1845, when there was only one.

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* The Society had already a collecting clerk.

The Charter cost the Society nearly £400 in fees and stamps, but this expenditure can be looked on as a good investment, because there can be little doubt that it paved the way to the grant by the Government of rooms in Somerset House. This took place in 1828, and it is interesting to note that the grant was made through the mediation of the President and Council of the Royal Society, the President being Davies Gilbert, who was on the council of the Geological Society. A capital expenditure of about £1,500 was required to adapt the rooms to the Society's purposes, and a further sum of £1,000 was expended six years later, when the accommodation was still further increased. Nearly £1,500 of the required amount was raised by subscription among the Fellows on these two occasions, and though the amount expended (including the cost of the Charter) was thus nearly £3,000, the Society, it will be seen, were the gainers, when it is remembered that they had as much space as they then required rent free, instead of the inadequate accommodation of the Bedford Street house, for which they had to pay £150 a year in addition to a premium. Subsequently, in 1874, the removal to the present rooms at Burlington House cost nearly £2,000, and once more the generosity of the Fellows came to the rescue, and a sum of over £1,000 was raised by subscription.

With the Charter the history of the Foundation and Constitution of the Society may be said to end, the most notable events in subsequent years being the establishment of the *Quarterly Journal* in 1845, and the removal to Burlington House. The Bye-Laws have from time to time, as I have already said, been revised, notably in 1889, when they were carefully gone through by a committee and to a certain extent re-cast.

Perhaps the most important addition to the Bye-Laws was the creation, in 1863, of a class of Foreign Correspondents, not provided for in the Charter, from whom the Foreign Members are selected. A proposal by the Council to create a somewhat similar class of Lady Associates was the subject of debate at a Special General Meeting last year, with the difference that, whereas the Foreign Correspondents are given no privileges, the Associates were, on a reduced scale of payment, to have practically all the rights of Fellows, except the power of voting at meetings and taking part in the government of the Society. The proposal was, however, thrown out by a small majority, and it would seem from the speeches made on that occasion that the opposition was considerably reinforced by the advocates of the admission of ladies as full Fellows, who were determined to have no half-measures. This, however, is a thorny subject, and it was fully dealt with in my address last year.*

Certain other matters have exercised the Fellows from time to time, and have been the subject of Special General Meetings. Of these the chief are the Museum and the method of selection of papers. With the latter subject I also dealt rather fully in my address last year,† and shall mention it incidentally later on. As to the Museum, which dates, as we have seen, from 1808, it is a very important collection, and it must be admitted that it does not receive the care or attention that it deserves. This is not the fault of the Council or Officials, but of circumstances, the chief of which are, on the one hand, the more urgent requirements of the Library, which swallow up all the available funds, and, on the other, the growth and easy accessibility of other museums. The retention of the Museum is largely a matter of sentiment, the collections having been practically all acquired by gift, and I, for one, think they should be retained as long as possible; but some day the requirements of the Library, in the way of space, will force the hand of the Council, and it will then have to decide on the future home of the Museum, and on the conditions under which it is to be parted with.

THE JUBILEE OF THE SOCIETY.

By November, 1857, the Society had been in existence for fifty years, but the event seems to have passed without any notice. This seems odd, but it may be remarked that not one of the original Founders was then living. The last survivor was Pepys, who died in 1856, but he had resigned his Fellowship in 1829. Richard Phillips had died in 1851, Aikin in 1854, and Greenough in 1855; all the others much earlier.* Our own Association was founded just a year after this event, and we, as you have heard from the Annual Report that has been read this evening, are fortunate in being able to commemorate our jubilee by honouring three of those who assisted in our foundation.† Of the Society's Council for 1857 there are still two survivors, the Earl of Ducie and Prof. Story Maskelyne, and though not on the Council that year, Sir Joseph Hooker (1852), Sir Richard Strachey‡ (1853), and Dr. Sorby§ (1856) had all served on the Council before the Jubilee year. In the list for 1907 there are no less than twenty-three names dating from 1857 or earlier, of whom the Rev. W. H. Egerton was elected in 1832, and has therefore been a Fellow for nearly seventy-six years. Four others, including Sir Joseph Hooker (elected in 1846), have sixty years to their credit. Of the rest we may mention Dr. Sorby, elected in 1850, Sir R. Strachey in 1851, the Rev. O. Fisher and Prof. T. Rupert Jones in 1852, the Earl of Ducie and Mr. H. H. Howell in 1853, Prof. N. Story Maskelyne in 1854, Lord Avebury, Professor Hull, and one of our own Founders, Mr. J. E. Saunders, in 1855, and Sir John Evans in 1857. Sir Archibald Geikie, the President for the Centenary year, and Mr. Whitaker fall only two years short, having been elected in 1859. It may also be noted that at the time of the Jubilee Prof. T. Rupert Jones was filling the position of Assistant Secretary.

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* *Proc. Geol. Assoc.*, vol. xx, p. 33.

† *Loc. cit.*, p. 31.

THE AIM AND WORK OF THE SOCIETY.

From the first the Geological Society set out with the idea of collecting and communicating facts, and this aim has always been maintained, anything in the nature of speculation, other than legitimate inferences drawn from facts, being systematically discouraged. This was very sound, and I may well quote Lyell, who, in the fourth chapter of his "Principles," writing of the foundation of the Society, says:

"But although the reluctance to theorise was carried somewhat to excess, no measure could be more salutary at such a moment than a suspension of all attempts to form what were termed 'theories of the earth.' A great body of new data was required; and the Geological Society of London, founded in 1807, conduced greatly to the attainment of this desirable end. To multiply and record observations, and patiently to await the result at some future period, was the object proposed by them; and it was their favourite maxim that the time was not yet come for a general system of geology, but that all must be content for many years to be exclusively engaged in furnishing materials for future generalisations. By acting up to these principles with consistency, they in a few years disarmed all prejudice, and rescued the science from the imputation of being a dangerous, or at best but a visionary pursuit."

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* Leonard Horner, Warburton, and Rev. E. J. Burrow, each of whom was elected in 1808, were still living, and Horner was a Vice-President for that year. He lived till 1864, and was President for the second time from 1860 to 1862.

† See foot p. 387.

‡ Sir Richard Strachey died, aged 90, on February 12th, 1908, a few days after this Address was delivered.

§ Dr. Sorby died, aged 81, on March 9th, 1908, whilst these pages were passing through the press.

Fitton, in reviewing a volume of the Transactions in the *Edinburgh Review* (vol. 28, p. 174), says the papers were characterised by "strict experiment or observation, at the expense of all hypothesis, or even of moderate theoretical speculation." This system can of course be, and sometimes has been, carried too far; but it has not prevented, for instance, the publication of such a paper as the classic one by Godwin Austen "On the Possible Extension of the Coal-Measures Beneath the South-Eastern Part of England."

The first idea of the founders of the Society was, as has been already said, a dining club, where the members could meet for discussion and exchange of views, but they soon extended their methods of carrying out their original aim as above defined. The fundamental notion of meeting has, however, always retained the first place, and must have proved of immense value to the science and to its individual followers, who could meet each other on common ground, and join in public discussion or private conversation at the fortnightly meetings. The other methods which have been adopted by the Society for furthering the progress of geology have been the amassing of the collections known as the Museum, to which reference has already been made; the formation of the splendid lending library of geological literature and maps now at Burlington House; the bringing out and revising from time to time of Greenough's Map, which for years held the first place as a geological map of England and Wales on such a scale (6 miles to the inch), till it was practically superseded a few years ago by the fine Index Map (4 miles to the inch) brought out by the Geological Survey; and last, but not least, the long series of publications issued by the Society under various names.

The publications have been very fully described by Mr. Woodward in his History, and so may be dealt with very shortly here. First came the quarto *Transactions*, of which Volume I was published in 1811. There were five volumes, the last two being each in two parts, the last part coming out in 1821. These were followed by a second series, commencing in 1822, and concluding in 1856, during which period seven volumes were published, each consisting of two or more parts. The appearance of these volumes or parts was very irregular, and as this often affected an author injuriously in the matter of priority, and caused delay in bringing valuable information before other workers, the expedient was devised of publishing accounts of the meetings, with brief abstracts of the papers read, in an octavo form known as *The Proceedings*. These began in 1827, and were issued at short intervals, proving very useful, till they were merged in the *Quarterly Journal* in 1846. The last-named famous serial began in 1845, in octavo form, and has continued to appear regularly from that time to the present, the last number issued being that for November, 1907, or No. 252, completing the 63rd volume. In 1897 an index to the first fifty volumes was issued, compiled by Mr. L. L. Belinfante, the assistant secretary. Of this work I can only say, that it has thoroughly deserved the praise that has been bestowed on it by all who have had occasion to use it. Other publications of the Society have been G. W. Ormerod's "Classified Index" to the Society's publications; J. F. Blake's arrangement of Mr. C. Davies Sherborn's manuscript catalogue of the "Type and Figured Specimens" in the Museum; Hutton's "Theory of the Earth," vol. iii; the annual series of "Geological Literature added to the Library," the material for which, prior to 1895, was included in the *Quarterly Journal*; and the "Abstracts of Proceedings" started in 1857. Mr. Sherborn is now at work on a comprehensive card catalogue of the Library, which, when completed, will form a valuable addition to the publications of the Society, if the Council decide to print it. Mention should also be made of the "History of the Geological Society of London," by Mr. H. B. Woodward, published in connection with the centenary celebrations, to which I have already expressed my acknowledgments.

As to the work of the Society, it is to be found in the various published volumes, and to enter on a description of it would almost involve a history of geology for the last hundred years. It may be said that there is no subject of geological interest which has not come before the Society in some form, and hardly any part of the world has escaped the notice of the contributors to its publications. Mr. Woodward has given an epitome of most of the important subjects which have engaged the attention of the Fellows up to a comparatively recent period. It will suffice to mention some of the more controversial. They include the Cambrian and Silurian disputes between Sedgwick and Murchison, the attacks on Devonian orthodoxy by Jukes, and later by Hicks, the North-west Highland succession, the Glaciation of Britain, *Eozoon canadense*, the Precambrian Rocks, and the Antiquity of Man.

Into the merits of the Cambrian and Silurian controversy I do not propose to enter. The hatchet has been buried, and the "blessed word" *Ordovician* written as its epitaph, but it cannot be denied that the treatment of Sedgwick by the Council on two occasions was unfortunate, and calculated to provoke resentment. The first was in 1843, and arose out of the proposed reduction by Warburton, the President, to a fit state for publication of the two papers he had read that year on "The Structure of North Wales," and "The Older Palæozoic Rocks." Sedgwick willingly agreed to this, but he was not prepared for the way in which Warburton deliberately altered them, so as to bring about what he thought was a compromise, and then sent them to press without allowing the author to see the proofs. The second occasion was in 1852, when a paper of his on the "Classification and Nomenclature of the Lower Palæozoic Rocks" was ordered to be printed in an abstracted form, but by some mistake was printed in full, whereupon the number was ordered to be recalled and the offending passages cancelled. The wording of the resolution by which this was effected was not at all happy, and the usual consequences of attempting to correct a mistake followed. Sedgwick thought it was intended to cast a reflection on him, and the resolution was afterwards rescinded, and another, in the nature of an apology, passed. The selection of papers for reading or publication has, as we have seen, been controlled from the very first (see p. 356). As I argued in my address last year, it is difficult to see how this could be otherwise, but much depends on the way in which the selections are made. There have no doubt been mistakes in the past; papers have been published that had better have been consigned to oblivion, and others have been rejected for reasons which it is difficult to understand. As a rule not much hardship has been done to the author, for if the paper is really worth printing some other medium has generally been found for bringing it before the public, and in some cases such rejected papers have become classics. I need only refer to Charlesworth's paper, in 1835, on the "Crag Formation"; that of Searles Wood, jun., in 1864, on "The Drift of the East of England"; and that of Mr. Whitaker, in 1867, on "Subaërial Denudation." I myself believe that much more satisfactory results will be obtained under the new system, which has been in force for the last three or four years, of fully discussing a paper before a permanent publication committee instead of allowing a single *ad hoc* referee to report to the full Council. At any rate there is more chance of consistency in the decisions of the Committee.

Besides the actual work done by the Society, their influence has often made itself felt, notably, as Mr. Woodward has pointed out, in the formation of the Government Department known as the Geological Survey.

One method of forwarding geology has never been adopted by the Society; I mean the organisation of excursions to places of geological interest. We, at any rate, ought not complain, as they have left the field clear for us, and there can be no doubt that we have reaped a considerable advantage in membership thereby. This gives me the opportunity of mentioning that our relations with the Society are, as they have been for many years, most cordial. There was a time when we seemed a little doubtful of their attitude towards us, as the following passage from an early number of our "Proceedings" will show, the occasion being an excursion to Watford in 1875, when the President of the Society, Mr. John Evans, as he then was, acted as Director: "In proposing a vote of thanks to the Directors, Mr. Lobley reminded the Members that that was the first occasion on which they had been led by a President of the Geological Society, and he trusted that this might be taken as evidence of the good will now existing between the two societies, each of which he hoped would continue to act vigorously in its own way; the Geological Society promoting the advancement, while the Geologists' Association furthered the diffusion, of geological knowledge." *

The excellence of our present relations can best be illustrated by the frequency of the interchange of officers between the Society and the Association. From 1892 to 1902 five consecutive Presidents of the Society had previously been, or, in one case, afterwards became, Presidents of the Association. Mr. Hudleston, Dr. Henry Woodward, the late Dr. Hicks, and Dr. Teall had all served us first, while Mr. Whitaker, who came to our chair straight from that of the Society, enjoys the unique distinction of having been, for exactly a fortnight, President of both bodies. Two of our Presidents, the late Professor Wiltshire and Mr. Monckton, have served the Society as Treasurer, and five, Professor Wiltshire, Mr. Hudleston, Dr. Hicks, Dr. Teall, and myself, as Secretaries. At the present moment Mr. Monckton and Professor Garwood are doubling the offices respectively of Treasurer and Secretary of the Society with those of Editor and Librarian of the Association, just as I myself did for some time the office of Secretary of the Society with that of Treasurer of the Association. Your newly-elected President, Professor Watts, still remains Secretary of the Society, an office which he has filled for many years with conspicuous ability.

THE COUNCIL AND OFFICERS.

As I have already pointed out, the management of the Society was, till 1810, in the hands of a committee, called the Committee of Trustees. It consisted at first of eight, and afterwards of ten, persons. The first Council, in 1810, was twenty-one in number, but from 1812 to 1822 there were two Treasurers, and from 1823 to 1827 three Secretaries (besides the Foreign Secretary), and the number of the Council varied accordingly. Since 1826 it has been twenty-three, as fixed by the Charter; and, though the Charter allows an indefinite number of Vice-Presidents, Treasurers, and Secretaries provided the prescribed number of the Council is not exceeded, in practice the numbers have almost always been the

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* *Proc. Geol Assoc.*, vol. iv, p. 285.

same—namely, four Vice-Presidents, one Treasurer, and three Secretaries, of whom the Foreign Secretary is one, the only exceptions being 1826, when there were three Secretaries besides the Foreign Secretary, and 1845, when there was only one.*

Mr. H. B. Woodward, in his History, has printed a complete list of the members of the Council (including the Committee of Trustees), and in this list will be found the names of most of the distinguished geologists of the last hundred years. Others have been chosen for their knowledge of business matters, or for their special interest in the Society. Many names occur of persons who have attained celebrity outside the walls of the Society, such as Darwin, Davy, Faraday, Sir Joseph Hooker, Huxley, Owen, and Wollaston, among scientific men; Sir John Herschel and Lord Rosse, the astronomers; Decimus Burton, the architect, and James Fergusson, the historian of architecture; Chantrey, the sculptor; John and George Rennie, the engineers; Sir John Franklin, the Arctic explorer; Hallam, the historian; Whewell, the versatile Master of Trinity; Samuel Wilberforce, Bishop of Oxford, and afterwards of Winchester; and the late Duke of Argyll, so often a Cabinet Minister. It is interesting to note that, of the thirteen Founders, all but Knight served on the Committee of Trustees or the Council, two of them—Greenough and Babington—being Presidents. Greenough, indeed, was never off the Council, serving till his death, in 1855, a period of nearly 48 years, which is the longest continuous period to anyone's credit. In actual length of service he was eclipsed by Lyell, who served 49 years, but this was in four terms with one year interval between each, the longest being 23. He was a Fellow for 56 years. Murchison served on the Council 42 years, in two terms of 37 and 5, with one year's interval, while Sir John Evans has completed 41 years in four terms. In contrast to Greenough's single term of 48 years is Sir Philip Egerton's 40 years, in eight terms covering a period of 50 years, during which time he was never more than three off the Council; he was 52 years a Fellow, and was more frequently re-elected to the Council than anyone else, the nearest to him in this respect being his friend and co-worker in the fossil fishes, Lord Cole, afterwards Earl of Enniskillen, who had seven terms, but his total years of service only come to 14. Godwin Austen, Daubeny, Prestwich, and Dr. Henry Woodward, have six terms each to their credit, with aggregates of 28, 11, 30, and 26 years respectively. Other long services, though not continuous, have been Leonard Horner and Sir Warington Smyth 36 years, W. J. Hamilton 34, Warburton 31, Wiltshire 30, J. Taylor 29, Buckland 27, and Professor Bonney, Professor Judd, Ramsay, and Carrick Moore 26 each.

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* In May, 1854, Edward Forbes resigned the Presidency on being appointed Professor at Edinburgh University, and W. J. Hamilton, who was one of the Secretaries, was elected President at a Special General Meeting, but the vacant secretaryship was not filled up, though the duties were undertaken by Prestwich.

Hamilton's is a really remarkable record. He was a Fellow 36 years, during which time he was on the Council 34, and in office 31! He was twice President, three times Secretary, in all for 21¼ years (16¼ being consecutive), and for six years he was Foreign Secretary. He became Secretary the year after his election as a Fellow, and after that was only one year off the Council till his death. Curiously enough he was never a Vice-President, the only other President who has not served as Vice being the Duke of Argyll. Hamilton really had no opportunity, for he was always serving in some other capacity, except the years immediately following his two Presidential terms, in which it was then customary not to call on the ex-Presidents to take up any work. Hamilton's is the only case of a President afterwards taking the office of Secretary. He also set the precedent of taking up the Foreign Secretary's duties, which has been followed by Smyth, Hulke, and Sir John Evans in succession, and bids fair to become an established custom.* It may be noted that Dr. Blanford is the only President who has afterwards served as Treasurer.

Other long periods of office (excluding the Vice-Presidency) have been Sir Warington Smyth, twenty-nine years, with seventeen as Foreign Secretary, the longest period for that office; John Taylor, twenty-five years, all as Treasurer, in two terms of five, and twenty years, the latter being not only the longest Treasurership, but the longest continuous period of being in office; Sir John Evans, twenty-three years; Wiltshire, seventeen years; Blanford, sixteen and a-half years; and Prestwich and De la Beche, fifteen years each.

There have been forty-three Presidents, forty-six Secretaries, sixteen Foreign Secretaries, and fourteen Treasurers. Of the Presidents, Greenough served three terms, and Buckland, Murchison, Lyell, Horner, Hamilton, and Sir A. Geikie two each. Except Greenough's first term, which extended over five and a quarter years, the Presidency has never been held for more than two years consecutively. W. Blake and Bostock each served one year only, and Edward Forbes a year and three months, resigning on being appointed to the Professorial Chair at Edinburgh University, making Hamilton's first Presidential term only a year and nine months. Daniel Sharpe was killed by a fall from his horse only a few months after taking up office, Colonel Portlock, his successor, who was elected in June, having his term proportionately shortened. No other case has occurred of the death of a President during office.

I have sometimes heard it said that Edward Forbes was the youngest President. He was 38, but Greenough, the first President, was only 29, and very close to him comes Lord

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* Sir Archibald Geikie, the retiring President, has just been elected Foreign Secretary in succession to Sir John Evans, Feb. 21st, 1906.

Compton (afterwards Marquis of Northampton), who was 30 when he assumed office. The Hon. Henry Bennet, the second President, was 36, Lyell 38, and Murchison 39. Since Forbes's day no President has been elected under 50, with the exception of Dr. Marr, who was 47. Two Presidents, Lord Compton and Huxley, subsequently became Presidents of the Royal Society, and it may be noted that five other Presidents of the Royal Society have served on the Geological Society's Council, namely, Sir Humphry Davy (on the Committee of Trustees), Davies Gilbert, Lord Rosse, Sir Edward Sabine, and Sir Joseph Hooker. Of these only Lord Northampton and Davies Gilbert were actually on the Council during their period of Presidency of the Royal Society.

Of the Secretaries Hamilton served three times, and Murchison, Godwin Austen, and J. Carrick Moore twice each. Next to Hamilton, for length, come Warington Smyth, Dr. Marr, and Prof. Watts,* who have each held office ten years. Since 1810 there have always been (except in 1845) at least two Secretaries, and as in these days nobody is of any importance who has not a "record" of some kind to his name, I may perhaps be pardoned for mentioning that the longest period of joint Secretaryship, namely, seven years, is shared between Hamilton and Carrick Moore from 1846† to 1853, and Professor Watts and myself from 1898 to 1905. The next longest was that of Professors Bonney and Judd, lasting six years.

Next to Smyth in length of service as Foreign Secretary comes Sir John Evans,‡ who has served thirteen years. De la Beche served twelve years and Heuland ten.

After Taylor, of the Treasurers, comes Gwyn Jeffreys with fourteen years, then Wiltshire with thirteen, Prestwich with twelve, and Blanford with ten and a-half. As has already been said, there were at one time two Treasurers, Daniel Moore and Taylor holding office together for the five years comprising the latter's first term. It is a curious fact that in 1822, when it was decided to reduce the number of Treasurers from two to one, no one was found willing to undertake the office, which remained vacant for a year, the banker of the Society apparently performing the duties. In 1823 Mr. Taylor resumed office, and, as we have seen, had charge of the finances for the next twenty years. On the death of his successor, Mr. J. L. Prevost, in November, 1852, the post remained vacant till the annual meeting in February, Leonard Horner in the mean time discharging the duties.

A word should be said about the permanent officials, of whom Mr. Woodward gives a list in the appendix to his book, a list of which any society might be proud. They include Webster, Lonsdale, Searles Wood, sen., S. P. Woodward, Edward Forbes, Ansted, J. de C. Sowerby, Nicol, Professor Rupert Jones, H. M. Jenkins, and Dallas. Several of these were Fellows of the Society, and Webster, during part of the time, served on the Council as Secretary. It may be noted that Forbes was afterwards President, Ansted Foreign Secretary, Lonsdale and Searles Wood had the Wollaston, and Professor Rupert Jones the Lyell Medal. It would be out of place to speak of the present Assistant-Secretary and his staff, further than to say that they worthily uphold the great traditions that have been handed down to them.

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* Prof. Watts has since been re-elected at the Annual Meeting, February 21st, 1908.

† In the list of Secretaries in the History of the Geological Society, and in the published Lists of Members, J. Carrick Moore is erroneously stated to have become Secretary in 1845, instead of 1846.

‡ Sir John Evans retired from the office at the Annual Meeting, February 21st, 1908.

The total number of Members and Fellows who have served on the Council or Committee of Trustees is 303, and, as according to Mr. Woodward, the number elected from the foundation of the Society to the end of 1906 was 4,603, it will be seen that only about six and a half per cent. of the Fellows have the prospect of a seat on the Council.

THE MEDALS AND FUNDS.

The Council not only manage the affairs of the Society, but they also act as Trustees of the various Funds which have been given or bequeathed to the Society from time to time, and I think it is universally admitted that they perform this responsible task with great care and judgment. There are five medals: the Wollaston, the Murchison, the Lyell, the Bigsby, and the Prestwich, to each of which, except the Bigsby, a fund is attached, and there are also two Funds, which have no medals, the Barlow-Jameson and the Daniel Pidgeon.

Of these, the Wollaston Medal, founded in 1828 by the gift of Dr. William Hyde Wollaston a few days before his death, is recognised as the highest honour which the Council can confer, and for some forty years it stood alone. It will be noted that the founder's letter refers to "researches concerning the mineral structure of the earth," and it must be remembered that Wollaston was a mineralogist. The widest possible interpretation has, however, been put on the words, and every branch of the science is represented among the recipients of the medal, the Council having decided almost from the first that palæontologists should be admitted. The first medallist was, most fittingly, William Smith, and it was on the occasion of conferring it on him that Sedgwick hailed him as the "Father of English geology."

The Murchison and Lyell Medals and Funds, founded by the respective wills of Sir Roderick Murchison in 1871, and Sir Charles Lyell in 1875, are somewhat alike in scope, the Lyell being the more richly endowed. Both are awarded annually, and in each case a portion of the Fund must accompany the Medal.

The Bigsby Medal, given biennially, was founded by the gift of Dr. J. J. Bigsby in 1877. The recipients must not have passed their forty-sixth birthday, and the founder quaintly added the reason for this limitation that the medallist is "probably not too old for further work, and not too young to have done much."

The Prestwich Medal was founded in 1896 by the will of Sir Joseph Prestwich, but the legacy was subject to the life of Lady Prestwich, and did not fall into possession till 1900. This is to be given triennially, and the whole of the income of the fund is to accompany the medal.

The Barlow-Jameson Fund, founded in 1876 by the will of Dr. H. C. Barlow in memory of his early teacher, Robert Jameson, is a most useful one, as it is left to the unfettered discretion of the Council how it is to be applied, provided it is for the advancement of Geological Science.*

The Daniel Pidgeon Fund has also proved very useful. It was founded in 1902 by Mrs. Pidgeon in deference to the wishes of her husband, Daniel Pidgeon, who died in 1900, as expressed in his will. His desire was to establish an annual grant for the promotion of Geological Original Research, with a limitation of the age of the grantees to 28. After much consideration the Council decided to use it as a kind of studentship, to be given in the summer on an undertaking by the grantee to do some definite piece of work. Recommendations of candidates for the grant are invited each year from various teaching bodies.

I believe I am right in saying that the Council of the Society do not desire any more Medals. The Medals are justly considered as marks of great distinction, but if there are too many the prestige attaching to them must be diminished, and it must become more difficult year by year to find fitting recipients. There cannot, however, be too many Funds, and the fewer conditions or restrictions attaching to them the better. Geologists as a rule are not blessed with long purses, and cases may not infrequently occur where they are much hampered in their investigations by the want of just such a sum as one of the Funds at the disposal of the Council would supply. What is really wanted is the creation of a sort of general fund which could be used for any purpose, as and when it may be required at the discretion of the Council. It is worthy of notice that Wollaston seems to have had this idea in his mind. In his letter announcing the gift nothing is said about a medal, and he particularly requests the Society to entitle the Fund "*The Donation Fund*," not "The Wollaston Fund"; and he goes on to express his confidence that "there now are, and hereafter will be, members who will make additional contributions to this 'Donation Fund.'" He probably thought that by not attaching his name to the Fund, he would attract gifts from others, and if any one wishes now to do what Wollaston seems to have intended, he must be prepared to sink his individuality, and resist the naturally strong temptation to have his name perpetuated and remembered by the generations to come.

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* The Council have this year made a grant from this Fund towards the purchase-money of the "greywethers" on Marlborough Downs, to rescue which from destruction a Committee has been formed.

It would not be out of place to remark here that the Society has had considerable benefits from gifts or bequests other than those founding the Medals and Funds. The most important of these have been £1,000 from Mr. Sydney Ellis (who was not a Fellow), £500 from Mr. Charles Lambert, £300 from Mr. John Brown (of Stanway), £200 from Mrs. Yates (a gift in lieu of an intended bequest by her husband, Rev. James Yates), and £500 which Greenough, ever solicitous for the interests of the Society, bequeathed, lest the cost of housing his legacy of books and collections should prove an encumbrance.

THE HOMES OF THE SOCIETY.

In my sketch of the history of the Society I have already referred to the various rooms or houses which they have successively occupied, but in accordance with the arrangement of this Address, it may be well to briefly summarise them :

The *Freemasons' Tavern*, in *Great Queen Street*, was the scene of the foundation dinner in 1807, and the meetings took place here even after the first rooms had been engaged in the Temple.

No. 4, *Garden Court*, *Temple*, was the first real home of the Society. The rooms, which were engaged in March, 1809, were on the ground floor. Here the cabinet was deposited, and the meetings of Committees took place.

No. 3, *Lincoln's Inn Fields* was the next home, and was engaged in April, 1810, the first meeting being held there in June. The whole house was taken, but it was shared with the Medical and Chirurgical Society, the two societies having a joint clerk and a common meeting room.

In June, 1816, a move was made to *No.* 20, *Bedford Street*, *Covent Garden*, where the Society had the upper part and basement of the house.

In 1828 the Society moved into the rooms which the Government had granted them in *Somerset House*, *Strand*, the first meeting held there being in November of that year.

Lastly, in 1874, their home was changed to *Burlington House*, *Piccadilly*, where they still occupy the fine set of rooms which the Government have so generously placed at their disposal.

THE FUTURE OF THE SOCIETY.

I have now dealt with the past history of the Society, and said something of its present state. The question naturally arises, What of the future? In the next hundred years will there be the work to do, and will there be the men to do it?

As to the work, it will no doubt seem to some that the vast amount of work done by the enthusiasts of the middle fifty years of the last century has left little to be done by those who follow. Such views are negatived by the past experiences of every science, and are the expressions either of a timidity which shrinks from attacking the problems waiting to be faced, or of an inertia that refuses to recognise their existence. It must be remembered that the early workers were pioneers, and that much of their work, great as it was, requires revision in the light of recent advances in petrology and palæontology. These subjects again require highly trained specialists to keep on adding to the knowledge gained by the earlier workers in the same fields.

As to the men, who will doubt that they will be forthcoming? We are apt to look on those of the early days as giants. There is a glamour about the names and achievements of Greenough and William Phillips, Conybeare and Buckland, Fitton and Lyell, Sedgwick and Murchison, Macculloch and Webster, Mantell and Lonsdale, De la Beche and John Phillips, Horner and Scrope. .The men of the middle period, though still great, seem of smaller proportions than their predecessors, perhaps because we have ourselves seen some of them in their later days. Such are Edward and David Forbes, Godwin Austen and Ramsay, Owen and Huxley, Daubeny and Hopkins, Prestwich and Warington Smyth, Egerton and Enniskillen, Nicol and Jukes, Harkness and Nicholson, Aveline and Selwyn, Searles Wood and Morris, Blanford and Hicks. Some there are who, happily still with us, make a bridge from that time to this. The veteran ex-Presidents, Dr. Sorby and Sir John Evans have already shown this session that their work is not done,* while Sir Archibald Geikie, to whose activity the success of the Centenary celebrations was largely due, might very well take for his motto the quaint phrase of Bigsby, omitting only the age so arbitrarily laid down. The men of our own day we see in like semblance with ourselves, and it will be for those who live a hundred years hence to compare their work with that of the giants of old. Our generation need not fear when we are able to show such men as Bonney and Judd, Geikie and Hudleston, Henry Woodward and Whitaker, Teall and Marr, Lapworth and Sollas†, to descend no lower than the rank of

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* At the meeting of the Society on December 18th, 1907, Sir John Evans read a paper on "Some Recent Discoveries of Palæolithic Implements"; and on January 8th, 1908, the late Dr. Sorby read a paper "On the Application of Quantitative Methods to the Study of the Structure and History of Rocks." See footnote p. 362.

† Professor Sollas was elected President at the Annual Meeting on February 21st, 1908.

President. We have only got to look round at the younger men at the Society's meetings or on our own excursions, to read their contributions to the *Quarterly Journal* and other publications (not forgetting our own PROCEEDINGS), to note the increased interest taken in geology at all our centres of education, and we shall be certain that the hope, adapted from the old "Bidding Prayer," with which our address to the Society concluded, will be fully realised, "that there may never be wanting in the future a train of worthy successors to that long line of distinguished men whose names have adorned your roll of Fellows in the past, the one object of whose scientific work has been the Elucidation of the Truth."

THE CENTENARY CELEBRATIONS.

I will now conclude with a few words describing the events connected with the celebration of the Centenary. This was fixed for convenience in September, and on the morning of the 26th of that month I, as your delegate, attended the meeting, which was held at the rooms of the Institution of Civil Engineers, those of the Society being quite inadequate to hold the great number who were present. This meeting, which was the real act of celebration, was for the purpose of receiving the congratulations of the delegates from our own country and from all parts of the world. Not only were practically all civilised countries represented, but a great variety of Universities, Scientific Institutions, and Surveys, with of course a preponderance of those dealing with geological subjects. The delegates approached the President in groups of countries, each group having its own spokesman. After he had delivered his speech, which had to be strictly limited as to length, his fellow countrymen presented their addresses and made way for the next group. The English delegates were divided into two batches, the first representing the Universities and other teaching institutions, and the second the Scientific Societies. The one was headed by the Universities of Oxford and Cambridge, represented by Professors Sollas and Hughes, the other by the Royal Society, for whom their Treasurer, Mr. Kempe, was the spokesman. The seating and ordering of all these groups of deputations was so perfectly arranged that the proceedings went off without a hitch, and the ceremony was got through in very good time. We reassembled in the afternoon to hear the President's interesting address on "The State of Geology at the time of the Foundation of the Geological Society."

In the evening the event was still further celebrated at a dinner in the Whitehall Rooms, at which nearly 300 were present, and it may be noted that this dinner was graced by the presence of ladies. Next day was occupied by visits to museums and other places of public interest, and in the evening there was a well-attended soirée at the Natural History Museum. Saturday, the 28th, was devoted to excursions, there being several of these within easy reach of London. The one to Reading, organised by the Geologists' Association, was very well attended, and quite cosmopolitan in character. So far as the Society is concerned this brought the celebrations to an end, but they were continued next week at Oxford and Cambridge, each of which University was conferring honorary degrees on some of the more distinguished of the foreign guests. I was fortunate enough to receive an invitation to Cambridge, and besides seeing the degrees conferred, I was most hospitably entertained by Professor and Mrs. Hughes at a soirée in the Sedgwick Museum, and by the Master and Fellows of St. John's (that nursery of geologists) at a banquet in their beautiful hall. Those who went to Oxford were, I need hardly say, made equally welcome.

What struck everyone who attended the celebrations, was the perfectly smooth way in which all the arrangements worked. Every detail seemed to have been carefully thought out, and nothing was left to chance. All this meant months of work. Settling the preliminaries, sending out the invitations, recording and sorting the acceptances, providing a place of meeting, planning the procedure at the reception of delegates, organising the excursions and museum visits, fitting up the Society's rooms for the reception of the guests, and arranging for the dinner and soirée.

For ensuring this satisfactory result we are indebted in the first place to the Council, but more particularly to the organising committee, with the President at its head, and we must not forget the share of the permanent staff. Where all worked so well it would be invidious to particularise, but I believe I am right in saying that after the President, to whose energy and power of attraction the great success of the gathering was mainly due, the chief burden fell on Mr. Rudler (who was responsible for the transformation of the Society's apartments into a series of reception rooms), and the Secretaries, Professor Garwood (who had charge of the arrangements for the dinner and soirée), and Professor Watts. It is to the last-named that the perfect organisation of the great delegates' meeting was due, and no one can really know what an amount of thought and actual hard work was involved in bringing this about. The result, however, was a veritable triumph, and Professor Watts must have reaped his reward in the congratulations he received.

Professor Watts is, as you know, your President-elect, and he is one whom I can recommend as my successor with the utmost confidence. I know him well; in an official character perhaps better than anyone else, for we worked together as joint

Secretaries of the Society for the long period of seven years, during which we never had the shadow of a difference. Moreover, he is no stranger to you, having served on the Council more than once, and having often acted as your leader on excursions. I feel, therefore, that in resigning the Presidency to him, I am placing it in safe hands.

I have only now to thank you for the attention with which you have listened to me this evening, and for the uniform kindness which you have extended to me throughout the two years during which I have had the honour to preside at your meetings and excursions. In return, I have tried to carry out the duties of the office to the best of my ability. The time has been for me a very happy one, and has passed all too quickly, but as all good things must have an end it only remains for me to say Farewell, and call my successor to the Chair.

ORDINARY MEETING.

FRIDAY, NOVEMBER 1ST, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

THE following were elected members of the Association: Albert Arthur Atkins, Professor W. S. Boulton, B.Sc., A.R.C.S., F.G.S., Henry Hargrave Fawcett, M. Odling, Alfred Ernest Snape, M.Sc., A.M.I.C.E., Sidney Herbert Snell, M.D., B.S., M.R.C.S.

The President stated that he had attended the celebration of the centenary of The Geological Society on September 26th, and had presented an illuminated address on behalf of the Association, which, by the courtesy of the Council of the Society, he was able to exhibit that evening. The text of the address was as follows:

"TO THE PRESIDENT, COUNCIL, AND FELLOWS OF THE GEOLOGICAL SOCIETY OF LONDON:

"We, the Members of The Geologists' Association, desire to offer our most cordial congratulations to the President, Council, and Fellows of the Geological Society of London on the completion of the Hundredth Year of the existence of the distinguished Society to which you belong.

"We recall with pride and admiration the stand made by the Society during the early years of its existence, which resulted in securing for Geology an independent position among the Sciences, and we recognise with gratitude that while at that time the Society refused to accept a subordinate position, so in after years those who directed its counsels never set themselves against the formation of other bodies proposing to investigate the same science.

"Thus it comes about that there are to-day a large number of Societies in this Country, the Colonies and abroad, our own Association being one of them, whose aim is the study of Geology, and who now unite in doing homage to The Geological Society of London as to the mother of them all. It is our sincere hope that your great Society may long continue to flourish, and that there may never be wanting in the future a train of worthy successors to that long line of distinguished men whose names have adorned your roll of Fellows in the past, the one object of whose scientific work has been the Elucidation of the Truth.

"Signed on behalf of the Geologists' Association,
"ROBERT S. HERRIES, President.
"GEORGE W. YOUNG, } Secretaries.
"ALFRED C. YOUNG, }

"September 26th, 1907."

The meeting then resolved into a conversazione. The following is a list of the exhibitors and their exhibits:

THE PRESIDENT: The Address presented on behalf of the Association to the Geological Society at the recent Centenary Gathering.
Yorkshire Jurassic Belemnites.

THE DIRECTOR OF THE GEOLOGICAL SURVEY: A selection of Maps and Memoirs published by the Geological Survey during the past year.

DR. G. ABBOTT: Concretionary forms of Silica (Beekite, etc.) from Torquay.

F. J. BENNETT: Micro-implements from Glacial Drift.

G. F. BROWN: Chalk fossils from Sutton, Harefield, and Woburn, Bucks.

R. H. CHANDLER: Igneous Rocks, Rhaxella Chert, and other erratics from Dartford Heath.

C. P. CHATWIN and T. H. WITHERS: Chalk fossils, including a very fine specimen of *Micraster cor-bovis* from Oxfordshire.

MISS M. C. CROSFIELD: Trilobites and Brachiopods from the Dufton Shales, Pusgill, Westmorland; Nummulites from near the Pyramids of Gizeh; and rock specimens from Nubia and the Sudan.

G. E. DIBLEY: Chalk Fossils. A large Gasteropod from *R. cuvieri*-zone, probably allied to *Natica gaultina*; a species of *Loricula*, a large and rare cirripede, from Cuxton; a set of thirty-six associated teeth of *Ptychodus mammillaris* from *T. gracilis*-zone, Cuxton; another set (lent by Mr. G. Bishop) of *P. decurrens* from the *H. subglobosus*-zone, Merstham.

J. LOUIS FOUCAR: Fossil wood (silicified) from the Selbornian of S.E. Devon; Tertiary (Thanet Sand, etc.) Fossils from well-borings in S.W. Essex.

JAMES FRANCIS: *Belemnites*, *Ammonites*, and Plant-remains from Jurassic rocks.

J. W. GARNHAM: A collection of carved Jade.

F. GOSSLING: *Ptychodus* Teeth, from Chalk near Croydon.

UPFIELD GREEN: Specimens of Cornish rocks.

C. J. GRIST: Eoliths from the *Elephas meridionalis* gravels of Dewlish, Dorset; and a similar implement from the Palæolithic gravels of the Frome valley.

W. F. GWINNELL: Rock-forming minerals and crystalline rock-specimens from the Alps, the Highlands, etc.

J. HOPKINSON : Copy of the Ray Society's Address to the Geological Society.
E. HOWARD ADYE : Petrological Microscope and Rock-sections.
MISS M. S. JOHNSTON : Axe heads and a few specimens from New Zealand.
A. E. KITSON : A large series of Lantern Slides, illustrating Geology and Physiography of Australia and New Zealand.
A. L. LEACH : Geological photographs of the coast near Tenby.
H. W MONCKTON : Album of Geological Photographs.
E. T. NEWTON (on behalf of Miss F. R. MILBORN) : *Hybodus* from Oxford Clay of Peterborough.
MISS E. PEARSE : Specimens of rocks from Plymouth District.
A. E. SALTER : Mineralogical specimens and silicified bones from Broken Hill mines of N.W. Rhodesia.
H. C. SARGENT : Erratics from Crich, Derbyshire, and photographs of Crich quarry.
C. DAVIES SHERBORN : Geological map of Armenia, prepared by Dr. Felix Oswald.
R. TERVET : Fossil Fishes from Scotch Oil-shales.
F. ROSS THOMPSON : Plant Remains from the Wealden.
LL. TREACHER : Photo-micrographs of Bryozoa from the Faringdon Sponge-gravel and from the Chalk.
E. WESTLAKE : Cycle-camping outfit, suitable for field-geologists.
H. J. OSBORNE WHITE : Japanese scroll-print, illustrating the mining and metallurgy of gold ; Mammalian bones and tufa-encrusted flints from bed of Thames near Wargrave ; Eolith-like flint from Norwich Crag of Thorpe, Norfolk ; Photos of N. American and Tyrolean Scenery.
W. WRIGHT : Roughly-shaped flint implements from North Downs of Surrey.
A. C. YOUNG : Erratic boulders from Crich.
W. PLOMER YOUNG : Geological lantern slides.

ORDINARY MEETING.

FRIDAY, DECEMBER 6TH, 1907.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

THE following were elected members of the Association : Ernest Howard Adye, Frederick Brunskill, B.A., B.Sc., Miss M. Cartwright, Percy Davis, Edward Percy Field, Fritz Jänchen, Henry John Jeffery, A.R.C.S., Joseph Jackson Lister, M.A., F.R.S., F.L.S., William Mawby, James Morrison, Roy Woodhouse Pocock, William J. Reynolds, Frederick John Richards, Ivor Thomas, B.Sc., Ph.D., William Robert Worthington Williams.

The President called attention to the fact that the Association had since its last meeting entered on its fiftieth year. He briefly summarised the account of its foundation as recorded in the Presidential address of Professor Rupert Jones for 1880. It originated from a meeting on November 17th, 1858, of three persons, Mr. J. E. Wakefield, Mr. J. Slade, and Mr. George Potter. Of these, Mr. Wakefield had for some years ceased to be a member, and, he regretted to say, died in 1903. Mr. Slade died in 1905, but Mr. Potter was happily still with us, and he was glad to see him present that evening. This was followed by a meeting on November 29th, at which it was resolved to form an Association, and a provisional committee was appointed. November 29th, 1858, therefore, might, he thought, be taken as the date when the Association came into existence, though the first general meeting was not held till December 17th, when a set of rules was adopted and a permanent committee appointed.

The following lecture was then delivered, "Notes on the Geology of the Tenby District," with special reference to the Carboniferous Limestone, by Arthur Leonard Leach. The lecture was illustrated by a series of lantern views taken by Mr. R. H. Chandler and the lecturer.

The President moved a vote of thanks to Mr. Leach for his interesting lecture; Mr. A. C. Young spoke, and Mr. Leach briefly replied.

ORDINARY MEETING.

FRIDAY, JANUARY 3RD, 1908.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association: Rev. Charles Roger Bower, Charles Ernest Pelham Brooks, Miss Alice Crawley, B.Sc., Wilmott Henderson Evans, F.R.C.S., M.D., Joseph Richard Farmery, Geoffry M. Jackson, George Horace Plymen, F.C.S., Richard Hill Tiddeman, M.A., F.G.S., C. H. Topham, Professor William Wright, F.R.C.S., D.Sc., F.L.S.

The following paper was then read, "On the Zones of the Chalk in the Thames Valley between Goring and Shiplake," by Charles P. Chatwin and Thomas H. Withers. The paper was illustrated by lantern slides, and was followed by an animated discussion, in which Dr. Rowe, Messrs. E. T. Newton, W. Whitaker, G. W. Young, Llewellyn Treacher, G. E. Dibley, C. Davies Sherborn, and W. P. D. Stebbing took part. Mr. Chatwin replied, and on the motion of the President a cordial vote of thanks to the authors was passed.

ANNUAL GENERAL MEETING.

FRIDAY, FEBRUARY 7TH, 1908.

R. S. HERRIES, M.A., F.G.S., President, in the Chair.

Messrs. D. Leighton and T. H. Withers were appointed Scrutineers of the ballot.

The following Report of the Council for the year 1907 was then read:

THE numerical strength of the Association on December 31st, 1907, was as follows:

Honorary Members	14*
Ordinary Members—	
a. Life Members (compounded)	165
b. Country Member (5s. Annual Subscription) .	1
c. Members (10s. Annual Subscription) . .	456
	636

This shows an increase of eighteen members as compared with the corresponding figures of the previous year.

During the year forty-nine new members have been elected.

The Council regret that the Association has lost nine members by death during the year: Miss Caroline Birley, C. W. Blackman, Sir James Hector, Bennett C. Polkinghorne, William Arthur Savage, Mark Stirrup, John Francis Walker, Augustus George Wildy, and B. Winstone.

Miss Caroline Birley, who joined the Association in 1890, was an enthusiastic student of geology, and frequently attended our meetings. She had visited many places of geological interest in various parts of the world, and had spared no pains to obtain additions to her extensive collection. Many of her specimens have been shown at our conversazioni. Under the provisions of her will her collection has been given to the British Museum and Manchester Museum.

Sir James Hector, who joined the Association in 1876, was for nearly forty years Director of the Geological Survey of New Zealand. He was educated at Edinburgh University, and after taking the degree of M.D. was chosen to accompany Captain Palliser's expedition to the interior of British North America, after which he wrote an important paper on the geology of Lake Superior. He went to New Zealand in 1861, and became Director of the Geological Survey in 1865, since which date his name figures largely in the local scientific literature. In 1876 he contributed a paper to our PROCEEDINGS "On the Geology of New Zealand with special reference to the Drift of that Colony."

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* By an error in last year's Report the number of Honorary Members was given as 15 instead of 14. The total should consequently be reduced to 618.

B. C. Polkinghorne was well known to many of the members as a keen geologist, although his professional duties prevented him from being a regular attendant at the meetings. He was an occasional exhibitor at the conversazioni, and, in conjuction with Mr. A. L. Leach, conducted an excursion to East Wickham in 1906. Although in failing health he acted as local Secretary at the Congress of the S.E. Union of Scientific Societies, held at Woolwich in June last. In October he went to Algiers under medical advice, where, however, he died dúring the closing days of the year.

Dr. W. A. Savage had latterly held an appointment at the Cottage Hospital, Mapumalo, Natal, where he died. Those members who took part in the Auvergne excursion in 1901 will not readily forget his kindness as a medical adviser.

John Francis Walker, although elected so long ago as 1874, did not often attend our meetings, having resided at York for the past twenty-five years. In him geology, and especially Yorkshire geology, loses one of her most distinguished sons. For many years past he had assiduously devoted himself to the study of the Brachiopoda, principally from the Jurassic and Lower Cretaceous formations, and of these he had gradually amassed a magnificent collection. His widow and son have, with great generosity, presented this to the British Museum. He has contributed many papers on his favourite subject to various scientific publications.

The finances of the Association continue in a satisfactory condition. The income in 1907 was slightly larger than in 1906, but the increase was entirely due to the efforts of the Secretary in disposing of publications and duplicate volumes from the library. The annual subscriptions and admission fees were practically the same in 1907 as in 1906. The expenditure for the year 1907 was £269 11s. 4d., as compared with £243 2s. 5d. in 1906. The increase of £26 is accounted for chiefly by extraordinary expenditure on "illustrations," being that part of the cost of illustrating Dr. Rowe's paper on the Chalk of the Isle of Wight which was incurred in 1907.

Three numbers of the 20th volume of the PROCEEDINGS have been published during the past year. A fourth number, consisting of Dr. Rowe's 5th and concluding part of "The Zones of the White Chalk of the English Coast," which it had been intended to issue in 1907, was delayed by various causes, but has now been published and distributed to the members.

The first portion of Volume XX, actually issued in 1907, consists of 208 pages, with seven plates and twenty-five text figures. The thanks of the Association are due to the various

GEOLOGISTS' ASSOCIATION.

Dr. Income and Expenditure for the Year ending Dec. 31st, 1907. Cr.

Dr.	£	s.	d.
To Balance from 1906	133	5	11
„ Life Compositions	15	0	0
„ Admission Fees	20	10	0
„ Annual Subscriptions	196	12	6
„ Dividends on Nottingham Corporation Stock ...	34	13	8
„ Sale of Publications	29	2	1
	£429	4	2

Cr.	£	s.	d.
By Printing PROCEEDINGS	113	8	0
„ „ Monthly Circulars	32	18	0
„ Miscellaneous Printing	3	13	0
„ Illustrating PROCEEDINGS and Circulars ...	40	13	11
„ Postage, Telegrams and Messages	38	19	4
„ Addressing	8	15	0
„ Library	1	0	0
„ Attendance, Lighting, Lantern, etc., at Evening Meetings	6	16	0
„ Excursions	14	11	2
„ Insurance...	2	15	0
„ Stationery	4	6	6
„ Miscellaneous Expenses	1	15	5
„ Balance at Bank of England, Dec. 31st, 1907...	159	12	10
	£429	4	2

We have compared the above account with the vouchers, and find it correct.
We have also verified the investment of £1,217 2s. 6d. Nottingham Corporation Stock.

January 21st, 1908.

J. VINCENT ELSDEN, } *Auditors.*
JAS. FRANCIS, }

There was, on December 31st, 1907, an outstanding liability of £6 8s. on account of "Attendance, etc."

authors for their respective contributions. For the use of blocks, clichés, and photographs used in illustrating the PROCEEDINGS thanks are due to H. M. Stationery Office, the Geological Society of London, W. G. Fearnsides, and Prof. S. H. Reynolds.

The additions to the Library during the year consist, as usual, chiefly of volumes of Transactions received from other societies in exchange, together with a few reprints of papers presented by individual authors. The Director of H.M. Geological Survey has again kindly presented various official Memoirs published by the Survey during the year.

The transfer of the Association's Library to the University of London (now representing University College) has taken place, in accordance with the terms of the resolution passed at the Special General Meeting held on July 6th, 1906, and the transaction is embodied in an agreement dated June 6th, 1907, made between the Trustees of the Association and the University of London.

The Library continues to be housed at University College, and the members of the Association will henceforth be able to use it as well as the Science Library of the College under the following conditions, in which the term "the Library" means the combined libraries referred to:—

> (1) Members of the Association shall have the right of reading all books in the Library when the Library is open.
>
> (2) They shall also have the right of borrowing the books in the Library except as hereinafter expressly provided.
>
> (3) The Library Committee or other proper authority of the University may in their discretion place any book or books upon a list of books not to be issued without special leave.
>
> (4) The Librarian shall have a discretionary power of refusing to issue any book without special leave, but on doing so he shall forthwith report the fact with a statement of his reason to the Chairman of the Library Committee or other proper College authority.
>
> (5) The Librarian shall also have a discretionary power before issuing any book of requiring a deposit of not more than one guinea to be made in the office of the College repayable on the return of the borrowed book, provided that this rule shall not apply to books transferred by the Association to the University, or to additions to be made to them by the Association, except so far as the Association shall from time to time determine.
>
> (6) Once a year with a view to an annual inspection of the Library the University may require the return of all

books at or before a specified hour on a specified day, and no book may be borrowed within three days of that date, not counting a Sunday.

(7) No member may borrow more than three books at a time without the special leave of the Librarian, and every book borrowed from the Library shall be returned not later than the date of the Association Meeting next but one following the date on which the book was borrowed, or within three calendar months from the last mentioned date whichever period shall be the shorter.

(8) If a borrowed book be lost or damaged or not returned to the Library when required in accordance with the Regulations, the borrower shall forthwith pay to the College the sum which the Library Committee shall estimate to be its value, or any less sum which the Library Committee shall in its discretion think proper to require, provided that the Librarian may in his discretion accept the return or replacement of the book in satisfaction of the borrower's liability under this regulation.

(9) On not more than twelve evenings in the year, when the Association shall meet at the College, the Library shall be kept open until 8 o'clock for the use of the members of the Association, and for the borrowing and return of books. Suitable dates for such meetings shall be arranged by the Association with the Provost of the College.

The Library is open for consultation and exchange of books between the hours of 9 a.m. and 5 p.m. daily, except on Saturday, when it is closed at 1 p.m. It is also open on meeting nights up to 8 p.m. Members who cannot attend at these times (and during the vacations) can have books sent to them on application to the Librarian, University College, London, W.C.

As soon as practicable the books will be rearranged and incorporated in the existing card catalogue of the Science Library of the College.

The majority of the serials have now been bound up by the College and are at length available for borrowing.

The amalgamation of the two libraries has placed a number of duplicate monographs of the Palæontographical Society at the disposal of the Council, and these have been offered for sale to the members.

The following is a list of the papers read at the evening meetings:

"The Constitution and Management of Scientific Societies" (Presidental Address), by R. S. HERRIES, M.A., F.G.S.

"On the Existence of the Alpine Vole, *Microtus nivalis*, in Britain during Pleistocene times," by MARTIN A. C. HINTON.

"The Igneous Rocks of the Bristol District," by Prof. S. H. REYNOLDS, M.A., F.G.S.

"The Carboniferous Limestone Sections of Burrington Combe and Cheddar," by T. F. SIBLY, B.Sc., F.G.S.

"Recent Researches in the Lower Carboniferous Rocks," by A. VAUGHAN, B.A., D.Sc., F.G.S.

"The Chalk Area of Western Surrey," by GEORGE W. YOUNG, F.G.S.

"The Geology of the Appleby District, Westmorland," by JOHN EDWARD MARR, Sc.D., F.R.S., F.G.S.

Lectures were delivered by HORACE W. MONCKTON, V.P.L.S., F.G.S., "On a Norwegian Snow-field and its Glaciers"; by M. M. ALLORGE, F.G.S., "A Geologist's Impressions of Mexico"; and by ARTHUR L. LEACH, "Notes on the Geology of the Tenby District."

The thanks of the Association are due to all these gentlemen.

The past year has been a very successful one, both as to numbers of Excursions and the attendance thereat. Some of the Excursions have been of exceptional interest. The increasing difficulty in finding fresh localities for half-days has led to our continuing to have more whole-days than formerly, but as these give greater opportunities for our country members to take part in our Excursions, we think that this departure is a good one.

We must call special attention to the September Excursion, to which the Fellows of the Geological Society and their Foreign guests were invited, a considerable number of whom attended. It has resulted in a very hearty invitation to the Association to visit the Paris Basin at the first opportunity.

The Members of the Association have again shown their disapproval of early starts from London.

Three visits to museums were made. There were five whole-day and twelve half-day Excursions, besides those at Easter and Whitsuntide and the Long.

The following is a list of the dates, localities, and directors:

DATE.	PLACE.	DIRECTOR.
March 2 . . .	British Museum (South Kensington)	Dr. A. Smith Woodward, F.R.S., F.G.S.
March 9 . . .	Bruce Castle Museum (Tottenham)	T. W. Reader.
March 16 . .	British Museum (South Kensington) Botanical Department	J. Britten, F.Z.S.
March 23 . .	East Wickham "Chalk Mines"	A. L. Leach.
March 29 to April 3 (Easter)	Plymouth . . .	W. A. E. Ussher, F.G.S.
April 6 . . .	Bushey and Croxley Green	J. Hopkinson, F.L.S., F.G.S., H. Kidner, F.G.S.
April 13 . . .	Tonbridge . . .	W. J. Lewis Abbott, F.G.S., and E. W. Handcock, F.G.S.
April 20 . . .	Lane End . . .	H. J. Osborne White, F.G.S.
April 27 . . .	Maidstone . . .	C. W. Osman, M.I.C.E.
May 4 (whole day)	Faringdon . . .	Ll. Treacher, F.G.S.
May 11 . . .	Crayford and Dartford Heath	A. L. Leach and R. H. Chandler.

DATE.	PLACE.	DIRECTOR.
May 18 to 22 (Whitsun)	Bristol and the Mendips	Prof. S. H. Reynolds, M.A. F.G.S., A. Vaughan, B.A., D.Sc., F.G.S., Prof. W. S. Boulton, F.G.S., and T. F. Sibly, F.G.S.
June 1 (whole day)	Seaford and Newhaven .	T. V. Elsden, B.Sc., F.G.S.
June 8 . . .	Crowborough . . .	The President.
June 15 . . .	Tring and Ivinghoe .	H. Kidner, F.G.S.
June 22 (whole day)	Hastings . . .	W. J. Lewis Abbott, F.G.S.
June 29 . . .	Guildford . . .	G. W. Young, F.G.S.
July 6 (whole day)	Rochester . . .	G. E. Dibley, F.G.S.
July 13 . . .	Laindon Hills . .	A. E. Salter, D.Sc., F.G.S.
July 20 (whole day)	Brill	A. Morley Davies, B.Sc., F.G.S.
July 27 . . .	Ipswich (Glacial) at the invitation of the Ipswich Field Club	G. Slater (President of the Ipswich Field Club).
August 15 to 23 (Long Excursion)	Appleby and District .	J. E. Marr, M.A., D.Sc., F.R.S.
September 28 . .	Reading . . .	H. W. Monckton, F.L.S., F.G.S., O. A. Shrubsole, F.G.S., and H. J. Osborne White, F.G.S.

Detailed Reports will be found in the PROCEEDINGS.

The loss to the Association through guaranteeing cheap railway tickets was £2 13s. 5d.

The Excursion Secretaries responsible for the conduct of the Excursions during the year were: Miss Pearse, and Messrs. Dibley, Kidner, Reader, Stebbing, A. H. Williams, Wilks, G. W. Young, and A. C. Young.

Thanks are due to the Directors of the Excursions, and also to the following for assistance and hospitality: The London and North Western Railway Company, and Colne Valley Water Company, at Watford; Sir John Hollams and Mrs. F. Hollams, at Tonbridge; Mr. W. H. Bensted at Aylesford; Messrs. A. Hunter, J. W. Puzey, and Mrs. Roberts, at Faringdon; the Rev. C. Doughty, at Alfriston; Col. H. H. Godwin Austen and Mr. D. Williamson, at Guildford; Mrs. Lewis Abbott, at Hastings; the Crowborough Brick Company and Mr. I. Middleton, at Crowborough; Mr. A. Brown, at Brill; the Council and Ladies' Committee of Ipswich Field Club, at Ipswich; and Mr. F. J. West, at Bruce Castle Museum.

H. M. Geological Survey have again generously presented various maps published during the year. These are a valuable addition to the resources of the Association.

Thanks to the promptitude of the Director, Dr. J. E. Marr, the Long Excursion pamphlet was on sale this year at the July meeting. The practice, started last year, of printing extra copies and placing them on sale in the district visited, was again adopted, and altogether 100 copies of the Westmorland pamphlet were sold during 1907.

The Association took part in the celebration of the Centenary of the Geological Society in September. The President attended as delegate for the Association, and presented an address, the text of which has appeared on page 376. Allusion has already been made to the excursion undertaken in connection with the celebration.

The following are the changes in the House List:

Mr. R. S. Herries, having filled the Presidential Chair for the past two years, now retires from that office. The Association is particularly indebted to him for the great care he has displayed in conducting the negotiations for the transfer of the Library to University College, by which the Association has gained substantial privileges. He has also contributed a thoughtful address on the management of Scientific Societies, which will be a most useful guide in the framing of regulations as it embodies the experience of many years. His constant attendance at meetings and excursions has also been of great support to the Secretaries.

Thanks are also due to Capt. Stiffe and Dr. A. Smith Woodward, who retire from the Vice-Presidency; to Mr. R. Holland, who finds himself compelled to resign the Treasurership on account of increasing business pressure. In him the Association loses a most efficient officer, who has managed the finances with great care during the past seven years and now leaves them in a very satisfactory condition; and also to Dr. C. W. Andrews and Mr. G. E. Dibley, who retire from the Council.

It will be a source of gratification to the members that the Association has now entered on its fiftieth year, which it will complete on November 29th next. To mark the event the Council have decided to bring out a volume dealing with the geology of those parts of England and Wales which have been visited by the Association during the course of its excursions. This will not be exactly on the lines of "The Record of Excursions" already published, which is now practically out of print, but will consist of a series of contributions by competent authorities on the geology of the various districts visited, under the general editorship of Messrs. H. W. Monckton and R. S. Herries.

The Council also feel sure that the members would wish that on such an occasion the opportunity should be taken of giving special recognition to the small band of survivors of those who took part in the foundation of the Association. Rule 22 empowers the Council to recommend persons, who have done some special service to the Association, as Honorary Members at the Annual General Meeting. They therefore recommend as Honorary Members the following persons:

Mr. William Norton Lawson, who was nominated a member of the first General Committee appointed at the first General Meeting on December 17th, 1858. He was subsequently appointed Secretary in 1860.

Mr. George Potter, who was one of three, Mr. J. E. Wakefield and Mr. J. Slade being the others, who met on November 17th, 1858, and decided to promote the foundation of the Association. Mr. Potter was again present at the resulting meeting on November 29th, 1858, when the Association may be said to have been founded. He was on this occasion nominated a member of the Provisional Committee appointed to draw up a Code of Rules, and to report progress to the first General Meeting held on December 17th, 1858. He was then placed on the first General Committee, a position which he was obliged to resign shortly afterwards owing to his leaving London. In view of the very active part taken by Mr. Potter in the foundation of the Society, the Council also recommend his election this year as a Vice-President.

Mr. James Ebenezer Saunders, who was present at the meeting on November 29th, 1858, and at that of December 17th, was nominated a member of the first General Committee, appointed at the latter meeting.

It was moved by Mr. A. S. Kennard and seconded by Mr. John Sheer and resolved that the report just read, including the Statement of Account, be adopted as the Report of the Association for the year 1907.

The President then formally proposed the election of the three persons, recommended in the Annual Report, as Honorary Members. This was carried *nem. con.*

The scrutineers reported that the following had been duly elected as Officers and Council for the current year :

PRESIDENT :

Professor W. W. Watts, M.A., M.Sc., F.R.S., Sec. G.S.

VICE-PRESIDENTS :

Upfield Green, F.G.S.
R. S. Herries, M.A., F.G.S.
E. T. Newton, F.R.S., F.G.S.
G. Potter, F.R.M.S.

TREASURER :

J. V. Elsden, B.Sc., F.G.S.

SECRETARIES :

G. W. Young, F.G.S.
A. C. Young, F.C.S.

EDITOR :

H. W. Monckton, V.P.L.S., F.G.S., F.R.N.S.

LIBRARIAN :

Prof. E. J. Garwood, M.A., Sec. G.S.

COUNCIL:

H. A. Allen, F.G.S.
J. V. Elsden, B.Sc., F.G.S.
Prof. E. J. Garwood, M.A., F.G.S.
Walcot Gibson, B.Sc., F.G.S.
Upfield Green, F.G.S.
R. S. Herries, M.A., F.G.S.
R. Holland.
T. V. Holmes, F.G.S.
Miss M. S. Johnston.
H. Kidner, F.G.S.
H. W. Monckton, F.L.S., F.G.S.
E. T. Newton, F.R.S.
G. Potter, F.R.M.S.
T. W. Reader, F.G.S.
A. E. Salter, D.Sc., F.G.S.
Miss Ida L. Slater.
W. P. D. Stebbing, F.G.S.
Ll. Treacher, F.G.S.
Prof. W. W. Watts, M.A., F.R.S.
W. Whitaker, B.A., F.R.S.
A. C. Young, F.C.S.
G. W. Young, F.G.S.

The best thanks of the Association were voted to the Officers, and Members of Council retiring from office, to the Auditors and to the Scrutineers.

The President then delivered the Annual Address, entitled, "The Centenary of the Geological Society."

On the motion of Mr. J. L. Foucar, seconded by Dr. C. G. Cullis, it was resolved: "That the President's Address just read be printed in full."

Mr. H. B. Woodward then moved: "That a cordial vote of thanks be given to Mr. R. S. Herries, the retiring President, for the excellent way in which he had carried out the duties of the office during the past two years." This having been seconded by the Secretary, Mr. G. W. Young, was carried by acclamation.

This terminated the Annual General Meeting.

ORDINARY MEETING.

FRIDAY, FEBRUARY 7TH, 1908.

Prof. W. W. WATTS, M.A., M.Sc., F.R.S., F.G.S., President, in the Chair.

The following were elected members of the Association: Mrs. Emily J. Alder, Capt. J. Dyer, A. Forbes, C.S.I.

There being no other business the meeting then terminated.

THE ZONES OF THE CHALK IN THE THAMES VALLEY BETWEEN GORING AND SHIPLAKE.

BY CHARLES P. CHATWIN AND THOMAS H. WITHERS.

WITH AN APPENDIX BY GEORGE J. HINDE, PH.D., F.R.S.

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I.—INTRODUCTION.

THE following paper contains the results of a detailed examination of those Zones of the Chalk which are exposed in the Thames Valley, near Reading. The area dealt with lies between Goring and Shiplake on the north bank, and between Streatley and Reading on the south, and with the exception of a small tract in the immediate vicinity of Goring, the whole is included in the portion of Sheet 268 of the one-inch Geological Survey Map, New Series, which is reproduced as Plate XXIV. The pits marked 1, 2 and 16 on the Plate are just outside the area of Sheet 268, and in that of the adjoining Sheet, No. 254.

Although the Chalk of this stretch of country has been examined by Professor Barrois,* and more recently by the Geological Survey,† little is known of its zoology, and in not a few of the sections neither the zones, nor their limits, have been correctly determined. The objects of our examination were to determine, from zoological evidence, the zones of the Chalk, and, where possible, to define their junctions.

In the first instance we had intended to work over a much larger piece of country, but Mr. H. J. Osborne White advised us that the small area dealt with in this paper would repay a closer inspection than either Professor Barrois or the Geological Survey had been able to give it. For general advice, and also for useful information about the position of many of the pits, we are greatly indebted to him.

Professor Barrois, in his account of this area, recorded at Whitchurch the zone of *Micraster cor-testudinarium ;* further east,

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* Charles Barrois. Recherches sur le terrain Crétacé supérieur de l'Angleterre et de l'Irlande. 4to. Lille, 1876. Pp. 147-149.

† "The Geology of the Country around Reading," by J. H. Blake and H. W. Monckton, *Mem. Geol. Surv.*, 1903. "The Cretaceous Rocks of Britain," by A. J. Jukes-Browne, *Mem. Geol. Surv.*, 3 vols., 1900-04. See vol. iii, pp. 205-222.

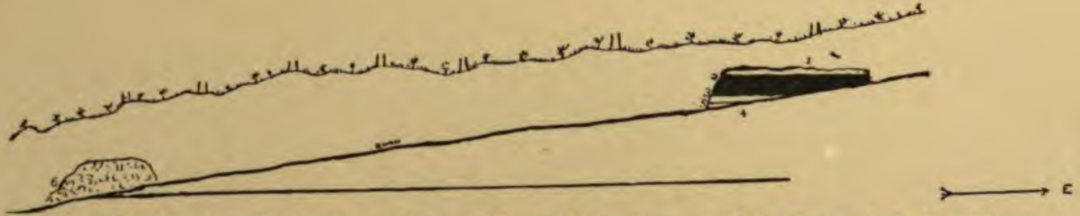

FIG. 28.—SECTIONS SEEN IN THE ROAD ON WHITE HILL, GORING.—*C. P. Chatwin & T. H. Withers.*

(Distance between the Sections = 28 yards.)

Showing the junction between the zones of *Holaster planus* and *Terebratulina.*

1. Loose powdery chalk. 2. CHALK ROCK.	ZONE OF HOLASTER PLANUS.	3. Hard, rough, nodular chalk. 4. Marl band. 5. Soft greyish chalk. 6. Grey, irregular blocky chalk.	ZONE OF TEREBRATULINA.

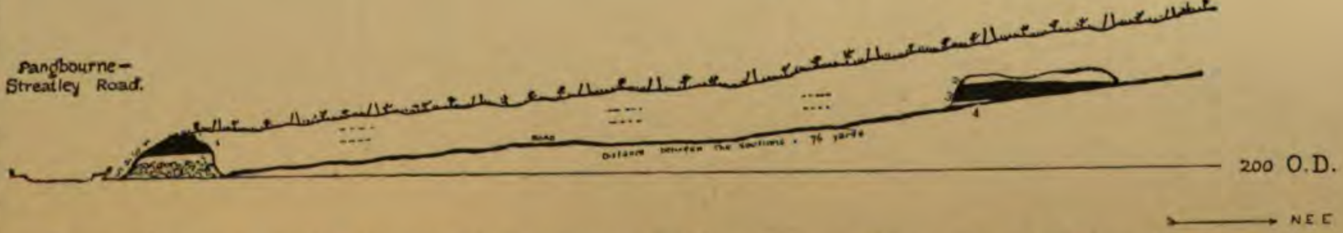
Pangbourne—Streatley Road.
1
3
4
ROAD
Distance between the Sections = 76 yards
200 O.D.
N E E

FIG. 29.—SECTIONS SEEN IN THE LANE AT BASILDON, SHOWING THE OUTCROP OF THE CHALK ROCK.—*C. P. Chatwin & T. H. Withers.*

1. Weathered Chalk Rock and rubbish deposited in recent times.

2. Lumpy and nodular chalk, glauconitic at base. 3. CHALK ROCK.	ZONE OF HOLASTER PLANUS.	4. Coarse, grey, rather nodular chalk. 5. Talus.	ZONE OF TEREBRATULINA.

at Hardwick House and Chazey Farm, the zone of *Micraster cor-anguinum;* and at Caversham, his zone of *Marsupites;* whereas the chalk of all these sections, as we shall show, is within the limits of the zone of *Micraster cor-anguinum*, as defined by Dr. Rowe. In the account of this district by the Geological Survey a few more sections were described, and doubt was thrown on the occurrence of *Marsupites* Chalk at Caversham, but little of importance was added to Professor Barrois' account.

With the exception of the quarry at Span Hill, all the pits visited have long been disused. In describing the sections on the two sides of the Thames Valley, we shall commence in each case with those on the west. We should mention that the general dip of the strata is in a south-easterly direction.

II.—EXPOSURES ON NORTH SIDE OF VALLEY (OXFORDSHIRE).

CLEVEMEDE, GORING. (No. 1.*)

A good section in the *Rhynchonella cuvieri*-zone is shown in a pit almost level with the Thames, adjoining Clevemede, Goring. The pit is in private grounds, but we were permitted to examine it by the kindness of the owner, Mrs. Fife. The section is much weathered, and is overgrown in parts with trees and shrubs, the talus having accumulated on the face of the pit to a height of some 15 ft. Flints are entirely absent. The rocky chalk seen at the base of the chalk exposed is probably not far above the top of the Melbourn Rock. Fossils are very numerous, and nearly all the typical fossils of this zone, including thirty-two examples of *Rhynchonella cuvieri*, were collected. The following section can be distinguished:

		ft.	in.
ZONE OF RHYNCHONELLA CUVIERI.	Gravelly soil	3	0
	Hard, white chalk . . . . *Rhynchonella cuvieri*, *Terebratula semiglobosa*, *Inoceramus labiatus.*	8	0
	Hard, rocky, rather yellowish chalk, gritty with fragments of fossils . . . . *Rhynchonella cuvieri*, *Terebratula semiglobosa*, *Conulus castanea*, *Cardiaster pygmæus*, *Hemiaster minimus*, *Discoidea dixoni*, *Cidaris clavigera*, *Inoceramus labiatus*, *Plicatula sigillina* (= *Dimyodon nilssoni*), *Spondylus latus*, *Spondylus* sp., *Serpula plana*, *Placopsilina cenomana.*	13	0
	Talus	15	0

WHITE HILL, E.N.E. OF GORING STATION. (No. 2.)

There are two small exposures (see Fig. 28) by the side of the road running up White Hill, one-third of a mile E.N.E. of Goring

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* The numbers of the sections are marked on the map, Pl. XXIV.

Station. The lower one (A) is in the *Terebratulina*-zone, and there *Terebratulina gracilis*, var. *lata* is very abundant. The sponge, *Verrucocœlia tuberosa*, described by Dr. G. J. Hinde in the Appendix (see p. 420, Fig. 31), was obtained from that section. In the second one (B), about 30 yards farther up the road, there is a good exposure of the Chalk Rock, but fossils are very difficult to extract from it, owing to its particularly hard and massive character. A stalagmitic crust of bright yellow colour, ¼ to ½ in. in thickness, was there noticed on the blocks of Chalk Rock, as well as on some of the fossils. This feature has not been observed in the other exposures of the Chalk Rock examined by us, either in this area or in other parts of Oxfordshire. Formerly the beds above the Chalk Rock, including the "top-rock" (described below), were seen in this road-cutting, and are described in the Survey Memoirs,* but at the present time these beds are not visible. The lower section (A) was probably not then exposed, as no mention is made of it.

The finding of three examples of *Terebratulina gracilis*, var. *lata* above the marl band in section B is noteworthy, as until now this fossil has never been recorded in this position in Berks., Bucks., or Oxon. So far as we can ascertain no specimens of *Micraster* have been found in this exposure. *Echinocorys scutatus*, *Spondylus spinosus*, and *Terebratula carnea* are the only fossils recorded from this section by the Survey; they were found in the nodular chalk (bed 6) formerly to be seen above the Chalk Rock.

Only beds 1—5 and 18 in. of bed 6 of the following section are now visible. The description of beds 6—8 is consequently from the Survey Memoir.

SECTION B.

		ft.	in.
ZONE OF MICRASTER COR-TESTUDINARIUM.	8. Soft, white chalk with a layer of flint about half an inch thick at the base . .	5	0
ZONE OF HOLASTER PLANUS.	7. ["Top-Rock"] Hard, yellowish rock in loose lumps, but without nodules. *Ventriculites*	1	0
	6. Nodular chalk, consisting of hard limestone lumps, embedded in loose, powdery chalk with a few scattered flints . .	12	0
	5. Chalk Rock. Hard, white limestone with green grains and a band of green-coated nodules, passing down into very hard compact yellowish rock with green grains and several layers of green-coated nodules	4	0
	Holaster planus, *Rhynchonella reedensis*, *R. limbata*, *Terebratula semiglobosa*, *Pleurotomaria perspectiva*, *Solariella gemmata*, *Ostrea semiplana*, *Spondylus spinosus*, *Oxyrhina* sp.		

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* Reading, p. 10; and Cret. Rocks, vol. iii, p. 208.

		ft.	in.
ZONE OF TEREBRATULINA.	4. Hard white rock passing down into rough nodular chalk . . . . . . *Terebratulina gracilis*, var. *lata* (three examples), *Inoceramus* sp., *Lima hoperi*, *Ostrea vesicularis*, *Plicatula sigillina* (= *Dimyodon nilssoni*), *Haplophragmium*.	2	6
	3. Buff-coloured shaly marl band (W. side of section) . . . . *Metopaster* sp., *Ostrea* (fragments), *Cytherella muensteri*, *C. ovata*.	0	3
	2. Soft, greyish chalk with harder lumps, just seen. *Terebratulina gracilis*, var. *lata* (common), *Bairdia subdeltoidea*, *Cytherella muensteri*, *C. ovata*.		

SECTION A.

ZONE OF TEREBRATULINA.	1. Greyish, irregular blocky chalk with marly veins and without flints, becoming softer and whiter below . . . . . . *Terebratulina gracilis*, var. *lata* (very common), *Rhynchonella cuvieri*, *Terebratula carnea*, *T. semiglobosa*, *Bourgueticrinus*, Asteroid ossicle, *Inoceramus cuvieri*, *Inoceramus* sp., *Ostrea vesicularis*, *Plicatula barroisi*, *P. sigillina* (= *Dimyodon nilssoni*), *Spondylus spinosus*, *Verrucocœlia tuberosa*.	6	6

GATEHAMPTON FARM, E. OF GORING. (No. 3.)

The following section, which is in the zone of *Terebratulina*, is seen on the slope above Gatehampton Farm, east of Goring. A fissure runs almost vertically down the middle of the pit, the chalk on both sides being slickensided. Near the top of the pit is a well-marked marl band, and this is probably the lower marl band seen some 16 feet below the Chalk Rock at Streatley (see below, p. 406). In this pit *Terebratulina gracilis* var. *lata* is very common above the marl band, but very rare below it, only one specimen having been found. Fragments of *Ostrea vesicularis* are very numerous in the bottom bed. The section has been described by the Geological Survey,* but no fossils have ever been recorded from it.

		ft.	in.
ZONE OF TEREBRATULINA	1. Firm, white chalk without flints . . . *Terebratulina gracilis*, var. *lata* (common)	7	0
	2. Buff-coloured, soft marl band . . . . *Terebratulina gracilis*, var. *lata* (fairly common), *Bourgueticrinus*, *Camerospongia capitata*, *Cytherella ovata*.	0	5
	3. Massive, firm, white chalk with a few scattered globular flints, and a thin tabular flint line 4 ft. below marl band . *Terebratulina gracilis*, var. *lata* (rare), *Holaster planus*, *Bourgueticrinus*, Echinoid spine, *Lima hoperi*, *Plicatula barroisi*, *Inoceramus*, *Ostrea hippopodium*, *O. vesicularis*, *Spondylus dutempleanus*, *Serpula ampullacea*, *Scalpellum* sp., *Hippothoa dispersa*, Fish-scales.	16	0

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* *Mem. Geol. Survey* (Expl. Sheet 268), Reading, p. 8, 1903.

HART'S LOCK WOOD. (No. 4.)

A very fine section is to be seen in the river bluff opposite Basildon, a little more than one mile N.W. of Coombe Lodge, near Whitchurch. It is the only exposure in the Thames Valley above Reading, which shows the whole of the zone of *Holaster planus* and its junctions with the zones above and below. The face of the pit is almost vertical, and about 20 feet of the chalk at the base is obscured by talus. In parts the pit is overgrown with trees and shrubs. The section has been previously described,[*] but, owing to the inaccessibility of the upper part of the quarry, nothing definite has hitherto been ascertained with regard to those beds. It has now been found possible to examine them in detail, and the measurements and descriptions are given in the section below. The rock-bed usually developed at the top of the *Holaster planus*-zone in this part of the country does not occur here, but the yellowish lumpy and nodular chalk (hard and soft mixed, bed 6 of the section given below) approximately marks the junction with the zone of *Micraster cor-testudinarium*, and therefore may be regarded as its equivalent. The Micrasters from this chalk (bed 6) are clearly passage forms, and have feebly inflated interporiferous areas; but just above this bed the Micrasters have strongly inflated "areas," and are undoubtedly of the *Micraster cor-testudinarium*-zone type. A remarkably fine specimen of *Micraster cor-bovis* was obtained from near the top of bed 5. The highest chalk (bed 7) seen in this section is the only exposure of the *Micraster cor-testudinarium* zone that we have observed in this area, and unfortunately very few fossils, except Micrasters, could be obtained from it. No fossils, other than Micrasters, appear to have been recorded from this section by the Geological Survey. The following is the section seen, with the fossils obtained from the various beds:

		ft.	in.
ZONE OF MICRASTER COR-TESTUDINARIUM.	7. White chalk, with many nodular and tabular flints in courses	15	0
	Micraster præcursor. *Bourgueticrinus* sp., *Metopaster parkinsoni*, *Rhynchonella limbata*. *Terebratula carnea*, *T. semiglobosa*, *Plicatula sigillina* (= *Dimyodon nilssoni*), *Serpula fluctuata*, *Bairdia subdeltoidea*, *Cytherella ovata*, *Clinopora lineata*, *Siphoniotyphlus plumatus*, *Spinopora dixoni*, *Proboscina angustata*, *Cristellaria rotulata*.		

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[*] *Mems. Geol. Survey*, Geol. London Basin, 1872, p. 47; Cret. Rocks, vol. iii, pp. 207-1904; Reading, pp. 9-10, 1903.

		ft.	in.
ZONE OF HOLASTER PLANUS.	6. Yellowish lumpy and nodular chalk (hard and soft mixed), with small elongate and globular flints . . . . *Micraster præcursor*, *Echinocorys scutatus*, var. *gibbus*, *Kingena lima*, *Rhynchonella reedensis*, *Terebratula semiglobosa*, *Ventriculites* sp, *Cytherella ovata*, *Stomatopora* sp., cf. *calypso*, *Cristellaria rotulata*.	3	0
	5. Nodular and lumpy white chalk, with very few flints . . . . *Micraster cor-bovis*, *M. præcursor*, *M. cor-testudinarium*, *Echinocorys scutatus*, var. *gibbus*, *Holaster placenta*, *Cidaris serrifera*, *Isocrinus*, *Metopaster parkinsoni*, *Terebratula carnea*, *T. semiglobosa*, *Rhynchonella reedensis*, *Spondylus latus*, *Plicatula sigillina* (=*Dimyodon nilssoni*), *Ostrea semiplana*, *O. vesicularis*, *Plocoscyphia convoluta*, *Ventriculites*, *Proboscina radiolitorum*, *P. ramosa*, *Stomatopora gracilis*.	16	0
	4. Chalk Rock.—Two distinct bands of compact yellowish rock, with green grains, and containing several bands of green-coated nodules; the bands separated by lumpy white chalk . . . . . . *Micraster præcursor*, *Holaster planus*, *Terebratula semiglobosa*, *Rhynchonella reedensis*, *Solariella gemmata*, *Trochus schlüteri*, *Pleurotomaria*, *Inoceramus* sp., *Ostrea semiplana*, *Reptomultisparsa congesta*.	5	0
ZONE OF TEREBRATULINA.	3. Nodular chalk passing down into more massive chalk . . . . *Terebratula semiglobosa*, *Inoceramus cuvieri*, Asteroid ossicle.	6	0
	2. Buff-coloured marl band . . . . . *Ostrea* sp., *Inoceramus* sp., *Cytherella ovata*.	0	3
	1. Grey, irregular blocky chalk, becoming whiter below. Much talus . . . . *Terebratulina gracilis*, var. *lata* (rather rare), *Inoceramus cuvieri*, *Ostrea vesicularis*, *Ptychodus* sp.	20	0

N.W. CORNER OF PARK OF COOMBE LODGE. (NO. 5.)

The road banks at the north-western corner of the Park of Coombe Lodge, near Whitchurch, show very small sections of firm, white, flaggy chalk, with solid, black nodular flints having a thin white cortex, and small globular flints which are cavernous. Tabular flint lines are also seen. The sections are in a very bad condition, showing no more than 18 in. of chalk No typical zonal fossil was found, so that we have no direct evidence as to the horizon of these exposures, but, judging from their position, they are probably in the lowest part of the zone of *Micraster cor-anguinum*. The frequent occurrence of radioles of *Cidaris clavigera* in these sections makes it probable that they are at about the same horizon as the pits behind the school at Whitchurch (No. 6), and at Bozedown Farm, a little farther east; for at both those places these radioles are very common at the base of the sections, and we have not found them in such numbers elsewhere. The following were the only fossils obtained by us:

Cidaris clavigera (radioles)
„ *sceptrifera*
Asteroid ossicle
Inoceramus (fragments)
Serpula plana
„ *fluctuata.*

WHITCHURCH. (No. 6.)

The base of the zone of *Micraster cor-anguinum* is seen in a pit behind the school-house, on the main road, north of the village of Whitchurch. A vertical face of about 30 ft. of chalk is exposed, but only the lower beds are accessible. At the base of the section there is just over 2 ft. of yellowish nodular chalk, above which the chalk is white and in massive beds. Nodular flints, black inside with a thin white cortex, occur in layers from 2 to 3 ft. apart, and between these layers are some scattered cavernous flints and some thin tabular bands. In the middle of the section a fault is seen, hading at an angle of about 70 degrees, the downthrow being 7 in. to the west, and another fault, hading at the same angle in the opposite direction, meets the former about 18 ft. from the bottom of the pit. Shattered bands of tabular flint occur along both lines of fault Professor Barrois describes a section "north of Pangbourne," which he refers to the zone of *Micraster cor-testudinarium*,* and this is probably the place, for we have failed to find any evidence of another exposure in this locality. The quarry, however, must have been very different when Professor Barrois saw it, for he gives the thickness as 15 metres, whereas now the exposure is no more than 10 metres. He mentions a bed of yellowish nodular chalk about 20 ft. from the top of his section, and a similar bed occurs at the bottom of the section now seen at Whitchurch. There is, however, a little doubt about the matter, and this doubt was evidently felt by the Geological Survey, for in one Memoir,† in reference to this exposure, it is stated "it can hardly be this one," and in a later Memoir‡ it is said "this must be the exposure." Professor Barrois records *Inoceramus cuvieri* and *Micraster cor-testudinarium* from the lower part of the pit. Mr. H. J. Osborne White§ has also found near the base of the section *Cidaris clavigera*, *C. sceptrifera*, and fragments of *Inoceramus*. Radioles of *Cidaris*, especially those of *Cidaris clavigera*, are very common near the base of this section. Two examples of *Kingena lima* were found here close together. The following is a list of the fossils collected by us:

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* C. Barrois, *op. cit.*, p. 148.
† *Mem. Geol. Surv.* (Expl. Sheet 268), Reading, p. 11, 1903.
‡ *Mem. Geol. Surv.*, Cret. Rocks, vol. iii, p. 215, 1904.
§ *Mem. Geol. Surv.*, Cret. Rocks, vol. iii, p. 215, 1904.

Micraster cor-anguinum
Cidaris clavigera
„ *hirudo*
„ *perornata*
„ *sceptrifera*
Holaster placenta
cf. *Hagenowia rostrata*
Salenia granulosa
Metopaster parkinsoni
Stauranderaster bulbiferus
„ *ocellatus*
„ sp.
Pentagonaster obtusus
Pycinaster sp.
Kingena lima
Rhynchonella reedensis
Inoceramus (fragments)
Ostrea vesicularis
Spondylus latus
Serpula fluctuata
„ sp.
Cytherella muensteri
Ventriculites cribrosus
Meliceritites lonsdalei
Oxyrhina sp.
Fish-scales.

Bozedown Farm. (No. 7.)

About half a mile along the road east of Whitchurch, at the side of some cottages behind Bozedown Farm, another section of chalk in the lower part of the *Micraster cor-anguinum* zone is seen. Prof. Barrois, who visited this section, referred it to the zone of *Micraster cor-testudinarium*,[*] and recorded from it *Inoceramus involutus*, *I. cuvieri*, *Rhynchonella plicatilis*, *Cidaris clavigera*, *Micraster cor-testudinarium*, *Echinocorys scutatus*, var. *gibbus*, Asteroid ossicles, and *Porosphæra globularis*. It will be seen that the only fossil really characteristic of the *Micraster cor-testudinarium*-zone is *Echinocorys scutatus*, var. *gibbus*, and even this fossil is often found in the lower part of the *Micraster cor-anguinum*-zone. *Inoceramus involutus* is much more typical of the *M. cor-anguinum*-zone, and *Micraster cor-testudinarium* is found in the base of the *M. cor-anguinum*-zone, as well as in the zone of *M. cor-testudinarium*. The above list has been quoted in the Survey Memoirs,[†] but in the Reading Memoir *Micraster cor-anguinum* is inserted in the place of *Micraster cor-testudinarium*.

The section now seen shows about 18 ft. of firm, white chalk, with three bands of massive tabular flint occurring at intervals of from 3 to 4 ft. These bands form a very conspicuous feature. The flint is, for the most part, solid, with a thin, white cortex. A few scattered cavernous flints are seen between the above bands. Fragments of a large *Inoceramus*, and radioles of *Cidaris clavigera*, are very common at the bottom of this section. The following are the fossils collected here:

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[*] C. Barrois, *op. cit.*, p. 148.

[†] *Mem. Geol. Survey* (Expl. Sheet 268), Reading, p. 12, 1903; Cret. Rocks, vol. iii, pp. 215, 216, 1904.

Micraster cor-anguinum
Cidaris clavigera
„ *sceptrifera*
Bourgueticrinus sp.
Rhynchonella reedensis
Terebratula semiglobosa
Spondylus latus
Inoceramus cuvieri
„ (fragments)
Serpula fluctuata
„ *plana*
Oxyrhina mantelli
Reptoceratites rowei
Stomatopora gracilis.

PIT BY ROAD RUNNING SOUTH FROM PATH HILL. (No. 8.)

Another exposure in the zone of *Micraster cor-anguinum* is seen on the west side of the road running south from Path Hill, one mile east of Whitchurch. A small fault runs down the centre of the pit, with a downthrow of 6 inches to the east. About half-way up the face of the pit there is a hard band of iron-stained chalk, but no fossils were found in it. Columnals of *Isocrinus* (= *Pentacrinus*) of a small size occur in the chalk beneath this iron-stained band. Many of the nodular flints are cavernous and contain flint-meal which, when washed, yields unusually large numbers of Ostracods, *Bairdia subdeltoidea* being the most common species. The following section is seen:

		ft.	in.
ZONE OF MICRASTER COR-ANGUINUM.	3. Firm, white, closely-bedded chalk with several layers of nodular flints . .	12	0
	Micraster cor-anguinum, *Helicodiadema fragile*, *Metopaster parkinsoni*, *Plicatula sigillina* (=*Dimyodon nilssoni*), *Serpula ampullacea*, *S. fluctuata*, *S. ilium*, *S. plana*, *Bairdia subdeltoidea*, *Berenicea papillosa*, *Berenicea* sp., *Clinopora lineata*, *Entulophora geminata*, *E. virgula*, var. *raripora*, *E. virgula*, var. *subgracilis*, *Homoeosolen* sp., *Meliceritites lonsdalei*, *Membranipora dentata*, *M. elliptica*, *Micropora hippocrepis*, *Nodelea durobrivensis*, *Onychocella depressa*, *Tervia subgracilis*, *Vincularia* sp.		
	2. Hard band of iron-stained chalk, soft in places	0	6
	1. Firm, white, massive chalk with layers of nodular and tabular flints in courses, and small scattered carious flints between them	9	0
	Micraster cor-anguinum, *Echinocorys scutatus*, *Cidaris hirudo*, *C. sceptrifera*, *Isocrinus* sp., *Pycinaster* sp., *Ostrea vesicularis*, *Inoceramus*, *Serpula fluctuata*, *Bairdia subdeltoidea*, *Cytherella muensteri*, *C. ovata*, *Geodia* (?) *wrighti*, *Membranipora* sp., *Stomatopora gracilis*, *S. granulata*, *Cristellaria rotulata.*		

HARDWICK HOUSE. (No. 9.)

A further exposure of the zone of *Micraster cor-anguinum* is to be seen by the side of the road leading off from the main road into Bottom Wood, above Hardwick House, 1½ miles east of Whitchurch. It extends for about 40 yards, and shows a maximum thickness of 14 feet. The chalk is firm, white and blocky, and contains many lines of solid, black, nodular flints, with a thin, white cortex, occurring at regular intervals. Small scattered cavernous flints occur between these lines. Fossils are not numerous, but two fairly large examples of the ovate form of *Echinocorys scutatus*, and pieces of *Micraster*, showing the labrum and the periplastronal area, were found, and are quite sufficient to determine the horizon. Prof. Barrois mentions this section,[*] and correctly refers it to the *Micraster cor-anguinum*-zone, though he did not find any fossils. The following are the fossils collected here:

Micraster (*M. c.a.*-zone type)
Echinocorys scutatus, var. *ovatus*
Cidaris perornata
„ *sceptrifera*
Pycinaster sp.
Stauranderaster sp.
Pentagonaster quinqueloba
Ostrea vesicularis

Spondylus latus
Serpula ampullacea
„ *fluctuata*
Spinopora dixoni
Proboscina fasciculata
Cristellaria rotulata
Flabellina cordata
Webbina sp.

MAPLEDURHAM. (No. 10.)

In the woods above the village of Mapledurham there is a large pit in the zone of *Micraster cor-anguinum*. A vertical face of about 45 feet of massive white blocky chalk is exposed, with courses of solid, black, nodular flints with a thin white cortex occurring at intervals of about 4 feet. Thin tabular bands of flint are also seen. Some of the large scattered flint nodules are carious and contain flint-meal. Large pieces of *Inoceramus* are extremely common at the base of the section, and these have been noticed by Prof. Barrois[†], and in the Survey Memoirs[‡], but no other fossils have been recorded. The following fossils were obtained from the base of the pit, the upper part being inaccessible:

Micraster cor-anguinum
„ *cor-testudinarium*
Echinocorys scutatus
Cidaris clavigera

Cidaris hirudo
Bourgueticrinus sp.
Pentagonaster quinqueloba
Kingena lima

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[*] C. Barrois, *op. cit.*, p. 148.

[†] C. Barrois, *op. cit.*, p. 148.

[‡] *Mem. Geol. Survey* (Expl. Sheet 268), Reading, p. 12, 1903; Cret. Rocks, vol. iii, p. 217, 1904.

Inoceramus cuvieri
„ *lamarcki*
Ostrea curvirostris
„ *hippopodium*
„ *vesicularis*
„ sp.
Plicatula sigillina
(=*Dimyodon nilssoni*)
Serpula ampullacea
„ *fluctuata*
Axogaster cretacea
Epiphaxum auloporoides
Porosphæra globularis
Stomatopora granulata

PARK FARM, EAST OF MAPLEDURHAM. (No. 11.)

Chalk in the zone of *Micraster cor-anguinum* is exposed in a pit in the middle of a field on the slope above Park Farm, east of Mapledurham. The pit is about 22 ft. deep, the lower beds being covered by talus for about 6 ft. The chalk is firm and white, and contains several bands of solid, black, nodular flints with a thin white cortex. Scattered flints occur, but they are not numerous. No tabular flint lines were seen. Three feet from the top of the pit a band of soft mealy chalk is seen, varying from 2 to 4 in. in thickness. A similar band of soft mealy chalk occurs in a pit in the same zone on the opposite side of the river, north of Sulham (see p. 408). The following fossils were collected in this pit.

Micraster cor-anguinum
Echinocorys scutatus
Cidaris clavigera
„ *hirudo*
„ *serrifera*
Helicodiadema fragile
Bourgueticrinus sp.
Isocrinus sp.
Metopaster parkinsoni
„ *uncatus*
Rhynchonella reedensis
Inoceramus (fragments)
Ostrea hippopodium
Ostrea vesicularis
Plicatula sigillina
(= *Dimyodon nilssoni*)
Spondylus spinosus
„ *latus*
Serpula ampullacea
„ *ilium*
Epiphaxum auloporoides
Porosphæra globularis
Stomatopora granulata
Reptomultisparsa sp.
Retecavea cretacea

CHAZEY FARM. (No. 12.)

On the north side of the road above Chazey Farm, west of Caversham, there is a large quarry in the zone of *Micraster cor-anguinum*. The chalk, of which about 45 ft. is exposed, is soft and white, the beds being more massive at the base than at the top of the quarry. Fragments of *Inoceramus* are very common, especially at the bottom of the section. Many layers of nodular flints are seen from 2 to 3 ft. apart, some of which are solid, black inside, with a thin white cortex; others are cavernous and contain remains of Bryozoa. Scattered flints occur between the layers, and a few tabular bands of flint were seen. The quarry has been described by Prof. Barrois[*], and in the Survey Memoirs,[†] but no fossils have hitherto been recorded from it. Mention has also been made of it by Messrs. Llewellyn Treacher and H. J. Osborne White.[‡] The following fossils were collected from this pit:

Micraster cor-anguinum
Echinocorys scutatus
Cidaris clavigera
„ *hirudo*
„ *serrifera*
Bourgueticrinus sp.
Nymphaster oligoplax
Kingena lima
Thecideum wetherelli
Spondylus spinosus
Pecten cretosus
Plicatula sigillina (= *Dimyodon nilssoni*)
Inoceramus (fragments)
Ostrea curvirostris
„ *vesicularis*
Serpula plana
Porosphæra globularis
Spinopora dixoni
Ventriculites sp.
Doryderma ramosum
Clinopora lineata
Crisina unipora
Entalophora echinata
„ *virgula*
„ *virgula*, var. *subgracilis*
Onychocella depressa
Proboscina radiolitorum
Siphoniotyphlus plumatus
Stomatopora spicea
Tervia subgracilis
Vincularia sp.

Caversham. (No. 13.)

Near St. Peter's Church, Caversham, there is a large quarry in the zone of *Micraster cor-anguinum*, showing about 70 ft. of chalk. Prof. Barrois, who described this section in 1876,[§] referred it to his zone of *Marsupites*, but he did not find any remains of the name-fossil, neither did he find any fossil at all characteristic of that zone. This section has also been described by the Geological Survey[||], mentioned by Messrs. White and Treacher,[¶] and has recently been visited by the Geologists' Association.[**] The chalk is soft, white, and in massive beds, but at the top of the pit it seems much softer and purer. Nodular bands of flint, with a few tabular layers, occur at intervals of from 2 to 6 ft., with scattered flints between the layers. These flints are mostly solid, black, with a thin white cortex, but others, especially the scattered ones, are cavernous and contain flint-meal. Fossils are fairly numerous, the most noteworthy being *Conulus albogalerus*, of which fossil two broken examples were obtained from the extreme top of the quarry. A fine example of *Epiaster gibbus* was also obtained. The following is a list of the fossils collected here, those marked with an asterisk being also recorded by Prof. Barrois. In addition to those in our list he records *Rhynchonella plicatilis*, *Terebratulina striata*, *Lima hoperi*, and *Serpula granulata*.

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[*] C. Barrois, *op. cit.*, p. 148.

[†] *Mem. Geol. Surv.* (Expl. Sheet 268), Reading, p. 12, 1903; Cret. Rocks, vol. iii, p. 217. 1904.

[‡] *Proc. Geol. Assoc.*, vol. xix, pt. 9, p. 392, 1906.

[§] C. Barrois, *op. cit.*, pp. 148, 149.

[||] *Mem. Geol. Surv.* (Expl. Sheet 268), . 12, 1903; Cret. Rocks, vol. iii, p. 217, 218, 1904.

[¶] *Proc. Geol. Assoc.*, vol. xix, pt. 9, p. 392, 1906.

[**] *Proc. Geol. Assoc.* vol. xx, pt. 3, p. 206, 1907.

**Micraster cor-anguinum*
Epiaster gibbus
Conulus albogalerus
Echinocorys scutatus, var. *pyramidatus*
**Cidaris clavigera*
* „ *hirudo*
„ *perornata*
„ *sceptrifera*
Holaster placenta
Metopaster parkinsoni
**Bourgueticrinus* sp.
Thecideum wetherelli
Terebratula carnea
Rhynchonella reedensis
**Spondylus spinosus*
Pecten cretosus
**Inoceramus* (fragments)
Ostrea vesicularis
Plicatula sigillina (= *Dimyodon nilssoni*)
Serpula fluctuata
„ *ilium*
„ *plana*
**Porosphæra globularis*
„ *patelliformis*
Berenicea papillosa
Entalophora virgula
Membranipora elliptica
Micropora hippocrepis
Onychocella sp.
Proboscina fasciculata
Stomatophora granulata
Cristellaria rotulata
Flabellina cordata
Haplophragmium sp.
Webbina sp.

PLAY HATCH, SONNING. (No. 14.)

In a field above the village of Play Hatch, north-west of Sonning, a pit in the zone of *Micraster cor-anguinum* shows about 30 ft. of firm, white chalk. The beds are much more massive at the base than at the top of the section. Layers of nodular flints occur at intervals of 2 ft. in the lower half of the section, those above being much more numerous, and the layers closer together. Many of the flints are cavernous and contain flint-meal. The following fossils were obtained from this pit. The absence of remains of *Cidaris* is noteworthy :

Micraster cor-anguinum
Echinocorys scutatus, var. *ovatus*
Holaster placenta
Bourgueticrinus sp.
Pycinaster angustatus
Rhynchonella reedensis
Thecideum wetherelli
Inoceramus (fragments)
Ostrea vesicularis
Plicatula sigillina (= *Dimyodon nilsonni*)
Serpula fluctuata
„ *plana*
Parasmilia mantelli
Porosphæra globularis
„ *pileolus*
Stomatopora granulata
„ *gracilis*
Membranipora sp.
Haplophragmium sp.

SPAN HILL, SONNING. (No. 15.)

By the west side of the road at Span Hill, north-west of Sonning a section well up in the zone of *Micraster cor-anguinum* is, exposed. This is still being worked, and a considerable portion of the floor has been dug out, thus forming two sections. In the lower one, below some lime-kilns, a band of iron-stained chalk, hard and soft mixed, 18 inches in thickness is seen. Nodules of iron pyrites were found in this band. Near the south-west end of the section there is a large "pipe".of red and brown sandy clay mixed with gravel. Fossils are plentiful, the most interesting occurrence being that of *Conulus albogalerus*, of which fossil four examples and some fragments were collected. Immature forms of *Salenia granulosa* are not uncommon in the flint-meal obtained from the cavernous flints in the upper part of this pit, but no adults have been found. The section now to be seen is as follows:

		ft.	in.
ZONE OF MICRASTER COR-ANGUINUM.	4. Soft, white, homogeneous, well-bedded chalk, with lines of massive black cavernous flints at intervals of about 2 ft. much talus	22	
	Micraster cor-anguinum, *Echinocorys scutatus*, var. *pyramidatus*, *E. scutatus*, var. *ovatus*, *Cidaris clavigera*, *C. hirudo*, *C. perornata*, *Conulus albogalerus*, *Cyphosoma* (radioles), *Helicodiadema fragile*, *Holaster placenta*, *Salenia granulosa*, *Bourgueticrinus*, *Rhynchonella reedensis*, *Thecideum wetherelli*, *Inoceramus*, *Pecten cretosus*, *Plicatula sigillina* (= *Dimyodon nilssoni*), *Spondylus latus*, *Serpula ampullacea*, *S. gordialis*, *S. plana*, *Porosphæra globularis*, *P. pileolus*, *Spinopora dixoni*, *Clinopora lineata*, *Crisina* sp., *Entalophora echinata*, *E. virgula*, *Homœosolen* sp., *Meliceritites lonsdalei*, *Membranipora grandis*, *Membranipora* sp., *Micropora hippocrepis*, *Nodelea durobrivensis*, *Onychocella depressa*, *O. lamarcki*, *Proboscina anomala*, *Siphoniotyphlus plumatus*, *Sparsicavea carantina*, *Stomatopora granulata*, *Tervia sub gracilis*, *Vincularia* sp.		
	floor of upper pit		
	3. Firm, white chalk with nodular flints . .	0	6
	Serpula ampullacea.		
	2. Iron-stained chalk (hard and soft mixed) .	1	6
	Conulus albogalerus, *Echinocorys scutatus*, *Cidaris serrifera*. *Porosphæra globularis*, *Cytherella muensteri*, *C. ovata*, *Cristellaria rotulata*.		
	1. Firm, white chalk with layers of nodular flints	3	0
	Conulus albogalerus, *Cidaris sceptrifera*.		
	excavation below lime-kilns		

From a comparison of the essential features of the tests of the Micrasters obtained from this section, and from the section at

Play Hatch, it is quite obvious that the former pit is much higher in the zone than the latter. This is further verified by the fact that in the section at Span Hill, *Conulus albogalerus*, which rarely occurs below the upper beds of the *Micraster coranguinum*-zone, is fairly common all over the section, while in the pit at Play Hatch this fossil seems to be absent. As these two sections are at about the same level, it may be inferred that a fault exists somewhere between them. It is probably the continuation of the fault which coincides with the western boundary of the Reading Beds outlier of Binfield Heath, a little to the north.

The Span Hill section is higher in the zone than that at Caversham, as is shown by a comparison of the respective faunas; the former section is probably about 60 ft. below the zone of *Marsupites.*

III.—EXPOSURES ON SOUTH SIDE OF VALLEY (BERKSHIRE).

Pit by Wantage Road, North of Streatley. (No. 16.)

The large pit by the side of the Wantage Road, north of Streatley, is one of those mentioned by Professor Barrois,* who referred the chalk exposed in it to the zone of *Terebratulina*, although no specimen of the name fossil was found. Professor Barrois also mentions finding fragments of Chalk Rock on the talus, but he did not see it *in situ.* Very few details are given, and the only fossils which he records are *Ostrea vesicularis*, *Spondylus spinosus*, and *Inoceramus* (near to) *labiatus*, but he does not say from what part of the pit he collected them. Mention is also made of this section in Mem. Geol. Surv., Cret. Rocks, vol. ii, p. 458, 1903, but no further details are given, and nothing is said of the Chalk Rock. It will be noticed that by Professor Barrois, and in the Survey Memoir, the thickness of this exposure is given as about 30 ft. only. This section is a very interesting one, as it shows the passage beds between the zones of *Holaster planus* and *Terebratulina*, the succession being typical of this horizon in this part of the country. The greater portion of this exposure, as will be seen by the section below, belongs to the *Terebratulina*-zone, and, excepting the small thickness of chalk below the Chalk Rock at Basildon, this is the only section in this area on the south bank of the Thames, where this zone can be seen. Unfortunately the upper beds of the section, which include the Chalk Rock, are very difficult of access, and much grass and talus has to be removed before they can be seen; consequently very few fossils could be obtained from them. A few large nodular flints were noticed in the beds below the lower marl band, their occurrence is rather unusual in the *Terebratulina*-zone in this area. The following is the section seen, with the fossils obtained from the various beds :

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* C. Barrois, *op. cit.*, p. 147.

		ft.	in.
ZONE OF HOLASTER PLANUS.	7. Firm, white, flaggy chalk, with nodular flints. No fossils seen	3	0
	6. Chalk Rock—Hard yellowish chalk with green grains and layers of green-coated nodules . . . . *Echinocorys scutatus*, var. *gibbus*, cf. *Pachydiscus peramplus*, *Terebratula carnea*, *T. semiglobosa*, *Serpula ampullacea.*	5	0
ZONE OF TEREBRATULINA.	5. Greyish nodular chalk.	6	0
	4. Buff-coloured, soft marl band	0	4
	3. Soft greyish chalk, becoming harder and whiter below . . . . *Terebratulina gracilis*, var. *lata* (two examples), *Terebratula semiglobosa.*	10	0
	2. Buff-coloured soft marl band	0	4
	1. Soft, white, massive, irregular blocky chalk, with marly veins and a few nodular flints ; much talus . . . . . . *Micraster cor-bovis*, *Holaster planus*, Asteroid ossicles, *Terebratula carnea*, *T. semiglobosa*, *Rhynchonella* sp., *Spondylus spinosus*, *Plicatula barroisi*, *P. sigillina* (=*Dimyodon nilssoni*), *Inoceramus cuvieri*, *Ostrea vesicularis*, *Bairdia subdeltoidea*, *Cytherella ovata*, *C. muensteri*, *Cristellaria rotulata.*	25	0

BASILDON. (No. 17.)

Two most interesting sections are seen in a lane near milestone "8" from Reading, by the north-west end of Basildon village (see Fig. 29, p. 391). The first one (A), at the angle of the roads, is the section described by Prof. Barrois,* and which shows the junction of the zones of *Holaster planus* and *Terebratulina*. A marl band is seen near the base of the section, above which there are a few feet of greyish nodular chalk, succeeded by a small exposure of the base of the Chalk Rock. In the greyish nodular chalk *Terebratulina gracilis*, var. *lata* is very common ; but in the Chalk Rock, owing to the smallness of the exposure, the presence of the root of a large tree, and the chalk and flint rubble which has been shot there, fossils were very difficult to find. It was only after several visits that we found *Echinocorys scutatus*, var. *gibbus* in the Chalk Rock, and so proved it to be in the zone of *Holaster planus*, for this fossil has never yet been found in the zone of *Terebratulina*. On the chalk exposed in this section we have noticed the presence of a quantity of Sodium Chloride, which appears on the surface of the chalk in the form of acicular crystals. This salt "sweats" out from the fossils obtained from these beds, just as it does from the fossils obtained from coast sections.

The second exposure (B), about 76 yards farther up the lane shows the whole thickness of the Chalk Rock, with four feet ot chalk above it. Micrasters are common in the higher bed, and the Chalk Rock yielded several of the typical fossils of the "*Reussianum*-zone" fauna as well as a fine example of *Conulus albogalerus*, which is a rare fossil in the Chalk Rock, or, indeed, in any part of the *Holaster planus*-zone. This section is the only good accessible exposure of the Chalk Rock visible on the south bank of the Thames between Moulsford and Marlow. A close examination of Section (B) shows an abrupt change in the dip of the Chalk Rock from 2° south to 3° north, or towards the Thames. This explains its appearance again at Section (A), at a lower level, the northerly dip being about equal to the inclination of the road. The following are the sections seen, with the fossils obtained from the various beds :

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* C. Barrois, *op. cit.*, p. 147.

SECTION B.

ZONE OF HOLASTER PLANUS.	4. Lumpy and nodular chalk, glauconitic at base, and there containing ragged glauconitic flints . . . . *Micraster cor-testudinarium*, *M. præcursor*, *Terebratula semiglobosa*, *Lima hoperi*, *Plicatula sigillina* (=*Dimyodon nilssoni*), *Cristellaria rotulata*.	4	0
	3. Chalk Rock. Hard, yellowish rock with green grains and layers of green-coated nodules . *Micraster leskei*, *M. præcursor*, *Echinocorys scutatus*, var. *gibbus*, *Conulus albogalerus*,[*] *Rhynchonella reedensis*, *R. plicatilis*, *Terebratula carnea*, *T. semiglobosa*, *Pachydiscus peramplus*, *Nautilus* sp., *Heteroceras reussianum*, *Solariella gemmata*, *Dentalium turoniense*, *Spondylus spinosus*, *Ventriculites*, *Coscinopora*.	5	0
	2. Nodular chalk, just visible.		

SECTION A.

ZONE OF HOLASTER PLANUS.	3. Chalk Rock. Hard, yellowish, rocky chalk with green grains and green-coated nodules and borings (capped by chalk and flint rubble) . . . . *Echinocorys scutatus*, var. *gibbus*, *Terebratulina striata*, *Terebratula semiglobosa*, *Solariella gemmata*, *Ostrea acutirosrtris*, *O. semiplana*, *Inoceramus*, *Spondylus spinosus*, *Porosphæra globularis*, *Cristellaria rotulata*, Fish-scales.	2	0
ZONE OF TEREBRATULINA.	2. Grey, coarse, rather nodular chalk . . . *Terbratulina gracilis*, var. *lata* (common), *Conulus subrotundus*, *Holaster*, *Cidaris serrifera*, *Spondylus spinosus*, *Plicatula sigillina* (=*Dimyodon nilssoni*), *Ostrea vesicularis*, *Inoceramus*.	3	0
	1. Marl-band (now obscured by talus).		

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[*] Dr. Rowe saw the specimen when this paper was read, and he regarded it as *Conulus vulgaris* (Lamarck). In his paper on "The Zones of the White Chalk," Part V (Isle of Wight), *ante* page 290, he records two examples, both crushed, of [*conulus*] *vulgaris* from the *Holaster planus*-zone. Mr. H. Woods has recorded *Echinoconus* [= *conulus*] *conicus* as occurring in the Chalk Rock, *Quart. Journ. Geol. Soc.*, vol. liii (1897), p. 397.

Road S.W. of Pangbourne Church. (No. 18.)

In a garden at the side of some cottages by the road running south-west from Pangbourne Church is a section in the *Micraster cor-anguinum*-zone, showing a maximum thickness of about 12 ft. The chalk is white, soft and lumpy. A prominent band of nodular flints running the whole length of the section can be traced near the base, the flints being black and solid, with a thin white cortex. Other flint lines occur, and scattered flints, some of which are cavernous, are fairly plentiful. The section was not in a very good condition, and fossils were not numerous. The following were collected mainly from the top of the section :

Micraster cor-anguinum
Cidaris clavigera
„ *hirudo*
„ *serrifera*
Holaster placenta
Metopaster sp.
Rhynchonella reedensis
Inoceramus sp.
Ostrea sp.
Plicatula sigillina (= *Dimyodon nilssoni*)
Serpula fluctuata
Bairdia subdeltoidea
Cytherella ovata
Berenicea papillosa
Homoeosolen ramulosus
Nodelea durobrivensis
Haplophragmium sp.

North of Sulham. (No. 19.)

On the edge of the woods about half a mile north of Sulham, near Pangbourne, another exposure in the zone of *Micraster cor-anguinum* is seen. The pit is about 20 ft. deep, and on the east side is talused and grass-grown. A band of soft, mealy chalk 3 in. to 5 in. in thickness is seen about halfway up the pit, the weathering of which allows the overlying chalk to fall away, so that the more massive chalk below stands out and forms a conspicuous ledge immediately beneath it. Lines of nodular flints are fairly numerous, these being solid and black, with a thin white cortex ; a thin tabular flint line occurs near the base of the section. A few small scattered flints were seen. Fossils are here rather rare but two examples of *Micraster cor-anguinum* were found. The following were the fossils collected :

Micraster cor-anguinum
Echinocorys scutatus var. *pyramidatus*
Holaster placenta
Cidaris sceptrifera
Ostrea hippopodium
„ *vesicularis*
Pecten sp.
Plicatula sigillina (= *Dimyodon nilssoni*)

South of Sulham. (No. 20.)

A small pit showing about 20 ft. of chalk belonging to the zone of *Micraster cor-anguinum* is exposed by the side of the road running south of Sulham Church, to the south of Pang-

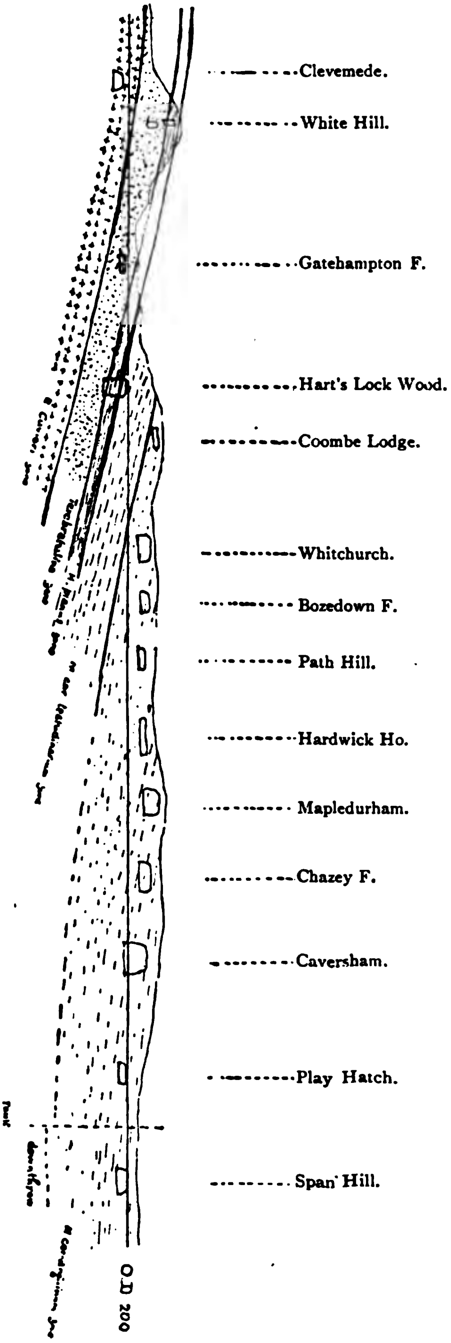

FIG. 30.—DIAGRAMMATIC SECTION TO SHOW THE RELATIVE POSITIONS OF THE PITS IN THE ZONES.—*C. P. Chatwin & T. H. Withers.*

(On a curved line, partly along dip and partly along strike. North side of the Thames.)

bourne. The chalk is firm and white, and the face of the pit is stained by surface-soil. Bands of nodular flints occur at intervals of from 2 ft. to 3 ft., with a few scattered cavernous flints between them. No tabular flint lines were seen. With the exception of fragments of *Inoceramus*, which occur commonly at the base of the section, fossils are not very numerous. The following were collected:

Micraster cor-anguinum
Echinocorys scutatus
Holaster placenta
Asteroid ossicles
Kingena lima
Inoceramus sp.
Ostrea vesicularis
Plicatula sigillina
(= *Dimyodon nilssoni*)
Spondylus latus
,, *spinosus*
Parasmilia sp.
Porosphæra globularis

WESTWOOD ROW, TILEHURST. (No. 21.)

At Westwood Row, Tilehurst,* to the north-east of Theale, there is a pit showing 25 ft. of soft white chalk of the zone of *Micraster cor-anguinum*. Flints are plentiful, and occur in layers about 2 ft. apart, with scattered flint nodules between the layers. Many of the flints are solid and black, with a thin white cortex; others, especially the scattered ones, are cavernous, and contain flint-meal with numerous Bryozoan remains. A small pipe of crimson clay is seen on the west side of the pit. Fossils, especially examples of *Micraster cor-anguinum*, are here common, and the following is a list of those collected:

Micraster cor-anguinum
Echinocorys scutatus
Cidaris clavigera
,, *hirudo*
,, *sceptrifera*
Bourgueticrinus sp.
Metopaster uncatus
Pentagonaster quinqueloba
Rhynchonella reedensis
Thecideum wetherelli
Inoceramus (fragments)
Ostrea vesicularis
Pecten cretosus
Pecten sp.
Plicatula sigillina
(= *Dimyodon nilssoni*)
Spondylus spinosus
Serpula plana
Spinopora dixoni
Porosphæra globularis
Berenicea papillosa
Membranipora sp.
Proboscina ramosa
Stomatopora granulata
Webbina sp.

IV.—REVIEW OF THE ZONES.

Zone of Rhynchonella cuvieri.

The only exposure of this zone which we have seen in the Thames Valley is that by the side of the Thames, adjoining Clevemede, Goring. Here the chalk is hard and white at the top, and passes down into intensely hard nodular chalk, ringing to the hammer, and containing fragments of fossils, chiefly *Inoceramus*. This chalk is probably not far above the Melbourn Rock. No marl bands occur, and flints are entirely absent. Probably the chalk seen in the railway-cutting north of Goring Station is in this zone, but we were unable to obtain permission to examine it. Owing to the absence of exposures, it has not been possible to define the limits of this zone.

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* *Proc. Geol. Assoc.*, vol. xix, pt. 9, p. 392, 1906.

Zone of Terebratulina.

Lithologically the chalk of this zone is firm, white, massive and flaggy, and is softer and greyish at the top: Flints are usually rare, but some of a subcylindrical shape are occasionally found, and sometimes a few nodular examples. Small nodules of iron-pyrites and seams of marl are not uncommon, and two prominent bands of buff-coloured shaly marl have been noticed at definite horizons near the upper limit of the zone. The upper one is seen about 3 ft. below the Chalk Rock at White Hill, Goring, and 6 ft. below that bed at Hart's Lock Wood. The lower one is seen in the section above Gatehampton Farm, and at Streatley both are seen, the upper one being 6 ft. and the lower one 16 ft. below the Chalk Rock.

At the commencement of our work, Mr. H. J. Osborne White told us that he thought that the persistent marl band which occurs a few feet below the Chalk Rock in this part of the country marked the junction of the zone of *Terebratulina* with that of *Holaster planus*, but that he had obtained no decisive evidence on this point. We notice that he has taken a marl band as the upper limit of the *Terebratulina*-zone in his description of a section at Shalbourne, in Wilts.* So far as the Reading district is concerned, however, we are of the opinion that the base of the Chalk Rock approximates more closely to the junction of the *Terebratulina* and *Holaster planus*-zones than does the marly layer above mentioned. At White Hill, Goring, we obtained three examples of *Terebratulina gracilis*, var. *lata*, between the marl band and the Chalk Rock, and at Basildon, on the opposite side of the river, this fossil occurs quite commonly in the same position, in association with *Conulus subrotundus*. Further, *Echinocorys scutatus*, var. *gibbus*, though fairly common even at the base of the Chalk Rock, has never been found below it in this district. Mr. Osborne White informs us that he has lately found *Micraster cor-bovis* and *Discoidea dixoni* in the chalk above this marl band near Henley; so that we now have for the fauna of this bed *Terebratulina gracilis*, var. *lata*, *Conulus subrotundus*, *Micraster cor-bovis*, *Discoidea dixoni*, and a few minor fossils. This fauna is certainly much more characteristic of the zone of *Terebratulina*, than of the zone of *Holaster planus*.

**Mem. Geol. Surv.* (Expl. Sheet 267) Hungerford, pp. 20, 21, 1907.

In our experience *Terebratulina gracilis*, var. *lata*, rarely occurs in any frequency in its own zone below the lower marl band in this district.

We have had no opportunity of taking the measurements of the thickness of this zone, as the lower limit is not seen in this area, but the section at Streatley shows nearly 42 ft. of it.

Zone of Holaster planus.

The zone of *Holaster planus* is represented in this part of the country by about 6 ft. of Chalk Rock at the base, succeeded by a variable thickness of white lumpy and nodular chalk, and at the top a bed of yellowish chalk varying in thickness and hardness. The whole of this zone is seen at Hart's Lock Wood, and the measurement for it there is 24 ft. In some parts of S. Oxon and S. Bucks, however, it is thinner. The upper limit of this zone is not infrequently marked by a thin, hard, compact, yellowish rock, termed the "top" or "upper rock," and it seems that where this is developed the thickness of the zone is decreased. It may therefore be surmised that the presence of the "top-rock" indicates arrested or diminished sedimentation. Nodular flints occur just above the Chalk Rock, and are usually glauconitic and ragged.

The Chalk Rock, which in this part of the country lies wholly within the zone of *Holaster planus*, presents one of the most striking of the lithological features of the chalk. This rock-bed at White Hill is very massive and compact, being white at the top, and yellow below, the upper half containing one band of green-coated nodules, while the lower half contains several. At Basildon it is similar, although less compact than at White Hill, but at Hart's Lock Wood it is represented by two distinct bands, separated by lumpy white chalk, and near the top of each band there are layers of green-coated nodules. The fossils of the Chalk Rock are much more common near the top of that bed than in any other part of it. *Holaster planus* seems to be more common in the *Terebratulina*-zone than in its own zone.

The only good exposures of the Chalk Rock on the south bank of the Thames, between Moulsford and Marlow, are seen at Streatley and Basildon, the only really accessible one being at the latter place. Map 268 (Reading) of the Geological Survey shows the outcrop of the Chalk Rock, and on the south bank of the Thames this is indicated as running roughly parallel to the river, and more than once turning at right angles to this course in tongue-shaped digressions between Streatley and Basildon, returning to a more regularly parallel course between Basildon and Pangbourne.

On the Geological Survey Map the Chalk Rock outcrop is not marked at the junction of the roads north-west of the Inn at Basildon Village, but we have shown (see p. 391 and Fig. 29) that the Chalk Rock is to be seen where the roads actually join, as well as some yards south-east of the corner, as the map indicates.

The "top-rock"—or the band of yellowish lumpy and nodular chalk which is seen at Hart's Lock Wood and which may be regarded as its equivalent—has been definitely determined by zoological evidence to mark the upper limit of the zone of *Holaster planus.*

At the present time the "top-rock" is not exposed in any of the sections in this area, but it was once seen at White Hill, Goring (see p. 393). It is, however, exposed a few miles farther north in a section on the escarpment at Aston Hill,* to the north-east of Watlington, and here we have obtained ample evidence to prove that it marks the upper limit of the zone of *Holaster planus.*

The lower limit of the zone has already been dealt with in connection with the zone of *Terebratulina;* the junction-beds between the zones of *Holaster planus* and *Terebratulina* can be seen at White Hill, Streatley, Basildon, and Hart's Lock Wood.

Zone of Micraster cor-testudinarium.

With the exception of 15 ft. of soft white chalk above the zone of *Holaster planus* at Hart's Lock Wood, we have seen no exposure of the zone of *Micraster cor-testudinarium* in the Valley of the Thames above Reading. There is, however, a considerable face of chalk in the railway-cutting west of Pangbourne Station, of which a section is given in the Survey Memoirs,† and the north-western end of this, judging from its position, cannot be far above the Chalk Rock. In our opinion the greater portion of the cutting near the railway bridge, a mile and a half north-west of the Station, belongs to the zone of *Holaster planus*, with some thickness of the *Micraster cor-testudinarium* zone above it. This view has been strengthened by the fact that some years ago Mr. Llewellyn Treacher found near the railway bridge, in the nodular chalk, a few feet above the base of the cutting, no less than twenty examples of *Echinocorys scutatus*, var. *gibbus.* At Pangbourne Station, owing to the dip of the beds, the cutting will probably be found to show the whole thickness of the zone of *Micraster cor-testudinarium*, for the zone ot *Micraster cor-anguinum* is exposed about half a mile to the south-west at pit No. 18. Unfortunately we have been unable to examine this exposure, owing to the consideration of the Directors of the Great Western Railway for our personal safety.

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* *Mem. Geol. Survey*, Cret. Rocks, vol. iii, p. 209, 1904.

† *Mem. Geol. Surv.* (Expl. Sheet 268), Reading, pp 10, 11, 1903, Cret Rocks, vol. iii, pp. 215, 214, 1904.

The junction of this zone with that of *Holaster planus* can be seen at Hart's Lock Wood, as already mentioned, but in the absence of exposures in this area, we have been unable to define its upper limits. Mr. Jukes-Browne* estimates the thickness of this zone in the Thames Valley as 60 ft. but in our opinion it is considerably less.

Zone of Micraster cor-anguinum.

The chalk of this zone is fairly soft and white, and contains many layers of nodular flints close together; also bands of tabular flints, which sometimes occur along the bedding planes, and numerous scattered examples. The nodular flints are, in some cases, solid, black, with a thin white cortex; others, especially the scattered ones, are cavernous and contain meal rich with remains of Bryozoa. These cavernous flints are well seen in the sections at Chazey Farm, Caversham, and Tilehurst.

On the north side of the Thames the base of this zone is first seen at Whitchurch, and proceeding towards Caversham, owing to the south-easterly dip of the beds, the horizon of the pits is gradually higher in the zone, although their level is about the same. The essential features of the tests of the Micrasters found in the first two pits, viz., Whitchurch and Bozedown Farm, indicate the extreme base of the zone, while at Caversham, *Conulus albogalerus* and the accompanying Micrasters, indicate the upper part of the zone. On the other side of the Thames, beds very near the base of the zone are seen at Pangbourne, and the dip of the beds brings the horizon of the pits at Sulham and Tilehurst much higher in the zone. Mr. Osborne White† mentions the occurrence of a hard band of yellowish chalk in this zone in the country farther west, and inclines to the opinion that it occurs at a definite horizon, 60-70 ft. below the upper limit of the zone. Near the base of the section at Span Hill we have noticed a hard yellowish band, which is probably at about the same horizon as the hard yellowish band mentioned by Mr. H. J. Osborne White. Another such band can be seen in the pit at Path Hill, which is at a considerably lower horizon.

The junction between the zones of *Micraster cor-anguinum* and *M. cor-testudinarium* is not seen in any of the sections.

Judging from all the exposures seen on the north bank of the Thames, the thickness of the zone of *Micraster cor-anguinum*, so far as it is represented, must be at least 200 ft.

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* *Mem. Geol. Surv.* (Expl. Sheet 268), Reading, p. 10, 1903.
† *Mem. Geol Surv.* (Expl. Sheet 267). Hungerford, p., 22, 1907.

V.—SUMMARY AND CONCLUSION.

Although we have been able to collect sufficient evidence to determine the zones exposed in all the pits in this area, our list of fossils is not large; for, with one exception, all the pits are now disused, and a good number of them are in the lower part of the *Micraster cor-anguinum*-zone, at which horizon fossils are usually scarce.

No chalk older than the zone of *Rhynchonella cuvieri*, and none newer than that of *Micraster cor-anguinum*, is exposed in this area.

We have definitely determined that the "top-rock"—or the band of yellowish lumpy and nodular chalk seen at Hart's Lock Wood, and which may be regarded as its equivalent—marks the junction between the zones of *Holaster planus* and *Micraster cor-testudinarium*.

The most important fact ascertained during this examination, is that the base of Chalk Rock marks the junction between the zone of *Holaster planus* and that of *Terebratulina* in this district.

The thickness of the zone of *Holaster planus* in this district is 24 ft., this measurement being taken from the section at Hart's Lock Wood.

At Hart's Lock Wood, near the top of the nodular beds above the Chalk Rock, and at Basildon just below that bed (see p. 406), we have noticed the presence of Sodium Chloride in some quantity. It appears on the surface of the chalk in the form of acicular crystals, which have a strong saline taste. We have looked for an explanation of its occurrence in such quantity in an inland section but as yet are quite unable to account for it, except on the supposition that it is a relic of the salt of the ocean in which the Chalk was deposited. The presence of common salt in considerable quantity in chalk of the *Micraster cor-anguinum*-zone at Woodford, near Salisbury, has been recorded by Mr. W. P. D. Stebbing in the report of the excursion of Easter, 1903. He mentions that the occurrence was regarded as unique in the district.* The subject of saline waters in the Chalk has been discussed to some length in the Survey Memoir on the Cretaceous Rocks, vol. iii, p. 438 *et seq.*, and to this chapter the reader should refer. Our attention has been drawn to a fluffy efflorescence on chalk, and we have ourselves noticed it in the field, but this has no saline taste, and differs in other respects from salt above mentioned.

In conclusion we must tender our best thanks to Dr. F. A. Bather and Mr. C. Davies Sherborn for kind encouragement and advice, to Dr. G. J. Hinde for describing the sponge in the Appendix, and reiterate our acknowledgments to Mr. H. J. Osborne White.

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* *Proc. Geol. Assoc.*, vol. xviii p. 147.

VI.—LIST OF FOSSILS.

Only the megascopic Foraminifera have been included in the following list. The Cyclostomatous Bryozoa have been kindly determined by Mr. W. D. Lang, and for lists of Bryozoa from several of the pits we are indebted to Mr. Llewellyn Treacher. For the most part the Asteroids have been kindly determined by Mr. W. K. Spencer, mainly from isolated marginal ossicles. It will be noticed that Vertebrate remains are only very poorly represented.

	Zone of Micraster cor-anguinum.	Zone of Micraster cor-testudinarium.	Zone of Holaster Planus.	Zone of Terebratulina.	Zone of Rhynchonella cuvieri.
Cristellaria rotulata, *Lamarck*	×	×	×	×	...
Flabellina cordata, *Reuss*	×	...	...	...	...
Haplophragmium sp.	×	...	...	×	...
Placopsilina cenomana, *d'Orbigny*	...	...	...	...	×
Webbina sp.	×	...	...	...	...
Camerospongia capitata, *T. Smith*	...	...	...	×	...
Coscinopora sp.	...	...	×	...	...
Doryderma ramosum, *Mantell*	×	...	...	...	...
Geodia (?) wrighti, *Hinde*	×	...	...	...	...
Plocoscyphia convoluta, *T. Smith*	...	...	×	...	...
Porosphæra globularis, *Phill.*	×	...	×	...	...
„ patelliformis, *Hinde*	×	...	...	...	...
„ pileolus, *Lamarck*	×	...	...	...	...
Ventriculites cribrosus, *Phill.*	×	...	...	...	...
„ sp.	×	...	×	...	...
*Verrucocœlia tuberosa, sp. n.	...	...	...	×	...
Axogaster cretacea, *Lonsdale*	×	...	...	...	...
Epiphaxum auloporoides, *Lonsdale*	×	...	...	...	...
Parasmilia mantelli, *Edwards and Haime*	×	...	...	...	...
„ sp.	×	...	...	...	...
Spinopora dixoni, *Lonsdale*	×	×	...	..	...
Berenicea papillosa, *Reuss*	×	...	...	...	...
„ sp.	×	...	...	...	...
Clinopora lineata, *Beissel*	×	×	...	...	...
Crisina unipora, *d'Orbigny*	×	...	...	...	...
Crisina sp.	×	...	...	...	...
Entalophora echinata, *Reuss*	×	...	...	...	...
„ geminata, *Hagenow*	×	...	...	...	...
„ virgula, *Hagenow*	×	...	...	...	...
„ „ var. raripora, *Beissel*	×	...	...	...	...
„ „ var. subgracilis, *d'Orb.*	×	...	...	...	...
Hippothoa dispersa, *Hagenow*	...	...	...	×	...
Homœosolen ramulosus, *Lonsdale*	×	...	...	...	...
„ sp.	×	...	...	...	...

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* See Appendix, p. 420.

	Zone of Micraster cor-anguinum.	Zone of Micraster cor-testudinarium.	Zone of Holaster Planus.	Zone of Terebratulina.	Zone of Rhynchonella cuvieri.
Meliceritites lonsdalei, *Gregory*	×	...	...	...	...
Membranipora dentata, *d'Orbigny*	×	...	...	...	...
„ elliptica, *Reuss*	×	...	...	...	...
„ grandis, *d'Orbigny*	×	...	...	...	...
„ sp.	×	...	...	...	...
Micropora hippocrepis, *Goldfuss*	×	...	...	...	...
Nodelea durobrivensis, *Gregory*	×	...	...	...	...
Onychocella depressa, *Hagenow*	×	...	...	...	...
„ lamarcki, *Hagenow*	×	...	...	...	...
„ sp.	×	...	...	...	...
Proboscina angustata, *d Orbigny*	...	×	...	...	...
„ anomala, *Reuss*	×	...	...	...	...
„ fasciculata, *Reuss*	×	...	...	...	...
„ radiolitorum, *d'Orbigny*	×	...	×	...	...
„ ramosa, *M. Edwards*	×	...	×	...	...
Reptoceratites rowei, *Gregory*	×	...	...	...	...
Reptomultisparsa sp.	×	...	...	...	...
Retecavea cretacea, *Edw.*	×	...	...	...	...
Siphoniotyphlus plumatus, *Lonsdale*	×	×	...	...	...
Sparsicavea carantina, *d'Orbigny*	×	...	...	...	...
Stomatopora gracilis, *M. Edwards*	×	...	×	...	...
„ granulata, *M. Edwards*	×	...	...	...	...
„ spicea, *Gregory*	×	...	...	...	...
„ sp. cf. calypso, *d'Orbigny*	...	...	×	...	...
Tervia subgracilis, *d'Orbigny*	×	...	...	...	...
Vincularia sp.	×	...	...	...	...
Bourgueticrinus	×	×	...	×	...
Isocrinus (= Pentacrinus)	×	...	×	...	...
Metopaster parkinsoni, *Forbes*	×	×	×	...	...
„ uncatus, *Forbes*	×	...	...	...	...
„ sp.	×	...	...	×	...
Nymphaster oligoplax, *Sladen*	×	...	...	...	...
Pentagonaster quinqueloba, *Goldfuss*	×	...	...	...	...
„ obtusus, *Forbes*	×	...	...	...	...
Pycinaster angustatus, *Forbes*	×	...	...	...	...
„ sp.	×	...	...	...	...
Stauranderaster bulbiferus, *Forbes*	×	...	...	...	...
„ ocellatus, *Forbes*	×	...	...	...	...
„ sp.	×	...	...	...	..
Asteroid ossicles	×	×	×	×	...
Cardiaster pygmæus, *Forbes*	...	...	...	...	×
Cidaris clavigera, *König*	×	...	...	...	×
„ hirudo, *Sorignet*	×	...	...	...	...
„ perornata, *Forbes*	×	...	...	...	...
„ sceptrifera, *Mantell*	×	...	...	...	...
„ serrifera, *Forbes*	×	...	×	×	...
„ sp.	×	...	...	...	...
Conulus albogalerus, *Leske*	×	...	...	...	...
„ castanea, *Al. Brongniart*	....	...	...	...	×

	Zone of Micraster cor-anguinum.	Zone of Micraster cor-testudinarium.	Zone of Holaster Planus.	Zone of Terebratulina.	Zone of Rhynchonella cuvieri.
Conulus subrotundus *Mantell*	...	...	...	×	...
Cyphosoma sp.	×	...	...	...	...
Discoidea dixoni, *Forbes*	...	...	...	...	×
Echinocorys scutatus, *Leske*	×	...	...	...	...
„ var. gibbus	...	...	×	...	...
„ var. ovatus	×	...	...	...	...
„ var. pyradmidatus	×	...	...	...	...
Epiaster gibbus, *Lamarck*	×	...	...	...	...
cf. Hagenowia rostrata, *Forbes*	×	...	...	...	...
Helicodiadema fragile, *Wiltshire*	×	...	...	...	...
Hemiaster minimus, *Agassiz*	...	...	...	...	×
Holaster placenta, *Agassiz*	×	...	×	...	...
„ planus, *Mantell*	...	...	×	×	...
Micraster cor-anguinum, *Leske*	×	...	...	...	...
„ cor-bovis, *Forbes*	...	...	×	×	...
„ cor-testudinarium, *Goldfuss*	×	...	×	...	...
„ leskei, *Desmoulins*	...	...	×	...	...
„ præcursor, *Rowe*	...	×	×	..	...
Salenia granulosa, *Forbes*	×	...	...	...	...
Serpula ampullacea, *Sowerby*	×	...	×	×	...
„ fluctuata, *Sowerby*	×	×	...	...	...
„ gordialis, *Schlotheim*	×	...	...	...	...
„ ilium, *Goldfuss*	×	...	...	...	...
„ plana, *S. Woodward*	×	...	...	...	×
„ sp.	×	...	...	...	...
Kingena lima, *Defrance*	×	...	×	...	...
Rhynchonella cuvieri, *d'Orbigny*	...	...	...	×	×
„ limbata, *Schlotheim*	...	×	×	...	...
„ plicatilis, *Sowerby*	...	...	×	...	...
„ reedensis, *Etheridge*	×	...	×	. .	...
„ sp.	...	...	...	×	...
Terebratula carnea, *Sowerby*	×	×	×	×	...
„ semiglobosa, *Sowerby*	×	×	×	×	×
Terebratulina gracilis, var. lata, *Etheridge*	...	...	...	×	...
„ striata, *Davidson*	...	...	×	...	...
Thecideum wetherelli, *Morris*	×	...	...	...	...
Dentalium turoniense, *Woods*	...	...	×	..	...
Pleurotomaria perspectiva, *Mantell*	...	...	×	...	...
Trochus schlüteri, *Woods*	...	...	×	...	..
Solariella gemmata, *Sowerby*	...	...	×	. .	...
Lima hoperi, *Mantell*	...	...	×	×	...
Inoceramus cuvieri, *Sowerby*	×	...	...	×	...
„ labiatus, *Schlotheim*	...	...	...	...	×
„ lamarcki, *Park*	×	...	...	...	...
„ sp.	...	...	...	×	...
„ (fragments)	×	...	×	×	...
Ostrea acutirostris, *Nilsson*	...	...	×	...	...
„ curvirostris, *Nilsson*	×	...	...	...	...
„ vesicularis, *Lamarck*	×	...	×	×	..

	Zone of Micraster cor-anguinum.	Zone of Micraster cor-testudinarium.	Zone of Holaster Planus.	Zone of Terebratulina.	Zone of Rhynchonella cuvieri.
Ostrea semiplana, *Sowerby*	...	...	×	...	...
„ sp.	×	...	...	×	...
Pecten cretosus, *Defrance*	×	...	...	...	...
„ sp.	×	...	..	...	...
Plicatula barroisi, *Peron*	...	...	...	×	...
„ sigillina, *Woodward* (=Dimyodon nilssoni, *Hag.*)	×	×	×	×	×
Spondylus latus, *Sowerby*	×	...	×	...	×
„ spinosus, *Sowerby*	×	...	×	×	...
„ sp.	...	...	...	×	...
„ sp.	...	...	...	...	×
Heteroceras reussianum, *d'Orbigny*	...	...	×	...	...
Nautilus, sp.	...	...	×	...	...
Pachydiscus peramplus, *Mantell*	...	...	×	...	...
Bairdia subdeltoidea, *Münster*	×	×	...	×	...
Cytherella muensteri, *Römer*	×	...	...	×	...
„ ovata, *Römer*	×	×	×	×	...
Scalpellum sp.	...	...	...	×	...
Oxyrhina mantelli, *Agassiz*	×	...	×	...	...
Ptychodus sp.	...	...	...	×	...
Fish-scales	×	...	×	×	...
Fish vertebræ	×	...	...	...	...

APPENDIX.

ON A NEW SPONGE FROM THE CHALK AT GORING-ON-THAMES.

BY GEORGE J. HINDE, PH.D., F.R.S.

THE fossil sponge submitted to me by Messrs. C. P. Chatwin and T. H. Withers appears to be a dictyonine-hexactinellid belonging to the genus *Verrucocœlia*, Etallon. The outer form of the specimen is fairly well shown, but the original siliceous skeleton has disappeared in the fossilization, and only here and there are faint casts of the spicular wall recognisable; sufficient, however, to indicate the group to which it belongs, and judging from its other features it may, in my opinion, be regarded as a new species with the characters described below.

Verrucocœlia tuberosa, sp. nov.

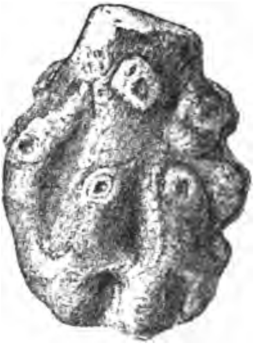

FIG. 31.—*Verrucocœlia tuberosa*, sp. nov. Side view showing the lateral tubes and the truncate summit osculum. Natural size. Chalk zone of *Terebratulina*. White Hill, Goring.

In outline, the sponge is ovate or barrel-shaped, with a truncated summit and rounded base. No stem is present, only a small projection in the centre of the base, and the sponge may have been sessile. Near the base the sponge-wall is folded to form rounded vertical ridges with deep intervening depressions, these folds pass upwards into cylindrical or compressed, nearly vertical, tubes, with rounded or truncate summits and circular or oval apertures, which communicate with the axial cavity of the sponge. Near the top of the sponge there is another series of much shorter tubes, which are irregularly disposed, and project directly outwards. The summit of the sponge consists of a large

(Concluded on p. iii of wrapper.)

circular oscular aperture, about double the breadth of the lateral tubes, which is the outlet of the central cavity.

Casts of a distinct reticulate dermal layer bounding small circular ostia are shown on some parts of the outer wall of the sponge, and more rarely some minute points indicate the quadrate mesh of the inner part of the wall; these are the only traces of the original skeleton now remaining.

The specimen is 46 mm. in height and 34 mm. in breadth. There are about eight of the lower series of longer upright tubes; these are 15 mm. on an average in length, and 7 to 9.5 mm. in breadth. Of the shorter tubes in the upper part of the sponge six are present; they are about 4 mm. in length by 7 mm. in breadth. The summit osculum is 15 mm. in breadth. The spicular wall is 1 mm. in thickness.

From *Verrucocœlia* (*Brachiolites*) *tubulata*, Toulmin Smith (Ann. and Mag. Nat. Hist., vol. i, 2 Ser., 1848, p. 366, pl. XV, fig. 7), the present form is distinguished by the lesser number and different form and arrangement of the lateral tubes and the well-defined oscular aperture. It should be noted, however, that the upper part of Toulmin Smith's type (now in the British Museum, Natural History) is defective, and it may have possessed originally an osculum, though that author states that there is generally no marked distinct opening to the central cavity, but that it is surrounded on all sides by the tubes. But even if *V. tubulata* possessed a distinct osculum, its other characters would sufficiently differentiate it from *V. tuberosa.*

At first sight the present species bears a nearer resemblance to *Verrucocœlia uvæformis*, Počta (Sitzungsber. d. königl. böhm. Gesellsch. d. Wissensch., 1885 (Prag.), p. 5, pl., figs. 5, 6), from the Bohemian Cretaceous, but here again the form, disposition and apertures of the lateral tubes markedly differ in the two species, and moreover in the Bohemian sponge there is no distinct osculum, only a small tube at the summit.

The only example yet known of this species was obtained by Messrs. Chatwin and Withers from the zone of *Terebratulina* in the lower section (A) on White Hill, E.N.E. of Goring-Station. (See page 394, and Fig. 28, p. 391).

THE CHALK AREA OF WESTERN SURREY.

BY GEORGE WILLIAM YOUNG, F.G.S.

(*Read June 7th, 1907.*)

THIS paper is in continuation of one read before the Association two years ago, when the Chalk area of the north-eastern part of the county was dealt with.*

The district under consideration extends from the River Mole on the east to the county boundary at Farnham on the west. The width at the eastern end of the area is about four miles, its northern and southern limits being marked by the towns of Leatherhead and Dorking respectively. Westwards the outcrop narrows until at Guildford, where it is cut through by the gorge of the Wey, it is but a mile wide. From Guildford to Farnham the Chalk is confined to the bold, narrow, long, and straight ridge known as the Hog's Back, and here the outcrop is only from half to a quarter of a mile in width. The district is bounded on the north by the Tertiary beds of the London Basin, and on the south by the Selbornian and Lower Cretaceous beds of the Weald.

In my previous paper I remarked upon the slight amount of detailed work that had been done upon the Chalk in Surrey, especially in regard to the higher zones. Those remarks apply with especial force to the western area. The Tertiaries above and the Greensands below have had their admirers and devotees, but the Chalk seems to have been left severely alone. The fullest account is that of Mr. Jukes-Browne in the *Survey Memoir*,† but the pits described therein are, without exception, confined to the face of the escarpment. The only description I have been able to find of a section in any other position is that of Hawkshill pit, near Leatherhead, to which Professor Seeley used to take his field-class.‡

Dr. Barrois gave a short account of the traverse at Guildford in his "Recherches,"§ and the Geologists' Association has also visited Guildford on several occasions, but the Chalk has usually been a minor feature of the excursion.

This neglect of the Chalk of Surrey seems strange when one considers the interest of its stratigraphy, and the varied physical beauties of the landscape which reward the observer at every step, and the problems concerning denudation which are continually being presented to him for elucidation.

I have followed the plan adopted in my previous paper of numbering every pit marked on the 6-in. Map, and a complete list will be found on pp. 441-450.

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* *Proc. Geol. Assoc.*, vol. xix (1905), p. 188.

† A. J. Jukes-Browne, "The Cretaceous Rocks of Britain," *Mem. Geol. Surv.*, vols. ii and iii.

‡ Handbook of the London Geological Field Class, 1892, p. 110.

§ "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et d'Irlande," 1876, p. 140.

The total number of sections in the area is 128, of which I have visited all but five. Owing to the narrowness of the outcrop the pits are, for the most part, arranged in two linear series, the one bordering the Tertiary and the other the Selbornian margin. In thirty-nine instances there is no exposure, the Chalk being entirely obscured by vegetation or soil-covered talus. I was much impressed with the great size of many of the abandoned pits, a large proportion of which are near the Tertiary border. They apparently date back to a time when "marling with chalk" was an agricultural operation far more widely practised than at present. Many of the very large ones are quite remote from towns, so it is unlikely that the chalk was got for building purposes.*

Owing to the rather complicated nature of the stratigraphy it will be more convenient to defer the detailed description of the physical features, and to deal first with the zonal succession.

THE ZONAL SUCCESSION.

UPPER CHALK = *Sénonian.*

Zone of Marsupites testudinarius.

A careful examination of the Chalk along the Tertiary border east of the River Mole having resulted in the finding of a continuous band of the *Marsupites*-zone,† it was only reasonable to suppose that the zone would continue west of that river until it joined with its proved occurrence in North Hampshire. In that county it has been found in many places, the most easterly being at Crondall, near Farnham, where its presence is recorded by Messrs. Treacher and White,‡ an observation I am personally able to confirm.

Dr. Barrois, whose work in Surrey was done at great speed, placed all the Chalk of that county which was in contact with the Tertiaries in the *Marsupites*-zone,§ but as this has not been accepted by English writers, a short explanation of the position may not be out of place.

In this connection it must be remembered that Dr. Barrois' zone of *Marsupites* in Surrey is more comprehensive than the limits he assigns to it elsewhere.

In correlating the Surrey Chalk with that of other localities he largely relied upon Mr. Caleb Evans's description of the Croydon-Oxtead section.* Mistaking the yellow band at the base of Evans's Purley beds to be the yellow sponge band found at the base of the *Marsupites*-zone in Thanet, Dr. Barrois was led to place the base of this zone in Surrey at too low a level, and so include a considerable thickness of Chalk in which *Marsupites* had never been found. Evans, in a subsequent paper,† admits having misled Dr. Barrois on this point.

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* On this point see Dr. Rowe's remarks, *ante*, p. 249; *Cret. Surv. Mem.*, vol. iii, p. 391; and Board of Agriculture Leaflet, No. 170. The latter can be obtained gratis and post free from 4, Whitehall Place, S.W.

† *Proc. Geol. Assoc.*, vol. xix, p. 196.

‡ *Proc. Geol. Assoc.*, vol. xix, p. 380.

§ *Op. cit.*, p. 139.

I have endeavoured to represent the different views in a tabular form, as below:

ZONAL CLASSIFICATION OF THE UPPER CHALK IN SURREY.

C. Evans, 1870.	Dr. Barrois, 1876.‡	Survey Memoir, 1904.	The Writer of this Paper, 1905-1907.
	TERTIARY	STRATA.	
Outcrop 1 mile wide, undescribed (100 feet in thickness).	*Marsupites.*	*Micraster cor-anguinum.*	*Marsupites testudinarius.*
Purley beds.			*Micraster cor-anguinum.*
Upper Kenley beds.	*Micraster cor-anguinum.*	*Micraster cor-testudinarium.*	*Micraster cor-testudinarium.*
	Micraster cor-testudinarium.		
Lower Kenley beds.	*Holaster planus.*	*Holaster planus.*	*Holaster planus.*

(The spaces in no way represent the relative thickness of the zones.)

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* "On Some Sections of Chalk between Croydon and Oxtead," *Geol. Assoc.*, 1870.

† *Proc. Geol. Assoc.*, vol. v, p. 154.

‡ *Op. cit.*, p. 139, but in another table, on p. 223, the Lower Kenley beds are shown as comprising the whole of the zones of *M. cor-testudinarium* and *H. planus*.

The result of this error in regard to the base of the zone, coupled with the absence of any record of *Marsupites* itself, was to cause later writers to consider the highest beds of chalk in Surrey as being of the zone of *Micraster cor-anguinum*, with a suspicion that the *Marsupites*-zone might possibly come in at the western end of the county.* This being so, it is necessary to examine in detail the evidence which led Dr. Barrois to assign the uppermost chalk in Surrey to the *Marsupites*-zone. In this instance he relied chiefly upon the lithological characters of the beds, for the only fossils he records are *Offaster corculum*, *Micraster cor-anguinum*, and *Echinoconus conicus*, a combination of doubtful zonal value. Mr. Jukes-Browne quotes him as having found these "near Guildford," but Dr. Barrois himself does not definitely say where he obtained them. His words are, "Le Nord du Hog's Back, et de toute la chaîne crétacée du Surrey au contact du tertiaire, est formé par une craie tendre avec peu de silex, et avec silex tabulaires; c'est le caractère mineralogique de la zone à *Marsupites*, elle contient de plus: *Micraster cor-anguinum* (Forbes), *Echinoconus conicus* (Breyn), *Offaster corculum* (Gold.)."†

Offaster corculum (Goldfuss) is recorded by Dr. Barrois as common in several English localities. The name has not been adopted by English writers, who have usually regarded it as a synonym of *Cardiaster pillula*,‡ apparently because Dr. Barrois' records are nearly all from places in which *C. pillula* is known to occur, and because he does not mention *C. pillula* in any part of the "Recherches." Failing to obtain definite information about this form I became desirous of seeing Goldfuss's original figure and description. After some little difficulty, owing to the confused state of the nomenclature, I found that Goldfuss had described it under the name of *Ananchytes corculum*.§

The genus *Offaster* was first separated by Desor, in 1858,‖ in which he placed various species referred by previous writers to the genera *Holaster*, *Ananchytes* (=*Echinocorys*), *Cardiaster* and *Toxaster*, but he carefully excluded "*corculum*" from among the species of his new genus. Schlüter¶ subsequently removed "*corculum*" from *Ananchytes* to the genus *Offaster*, but the reasons for his doing so are not very obvious.

In *Echinocorys* (=*Ananchytes*) the anus (periproct) is either on the base or at the margin, while in *Holaster*, *Offaster*, and *Cardiaster* it is placed well above the margin, on the posterior portion of the test. The position of the anus in Goldfuss' figure agrees more with *Echinocorys*[*] than with *Offaster*, and it seems to me unfortunate that Schlüter should have removed it from the genus in which Goldfuss originally placed it, and in which Desor was content to leave it. So far as I have been able to ascertain, Schlüter is the only author who has removed *corculum* from its original genus, and he is wrong in quoting Desor (among the synonyms) as having called it "*Holaster*" *corculum*. The principal point on which Goldfuss relied for separating *corculum* from the commoner species (*Echinocorys vulgaris*, Breyn. = *E. scutatus*, Leske) is the position of the pores in the ambulacral plates. In the latter case they occur nearly in the centre of the plate, but in *corculum* they are closer to the lower edge.

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* A. J. Jukes-Browne, *op. cit.*, vol. iii, p. 180.

† "Recherches," p. 139.

‡ Whether the species *pillula*, Lam., should be assigned to *Cardiaster* or to *Offaster* I must leave the experts to settle, I merely adopt Dr. Rowe's term.

§ "Petrifacta Germaniæ, 1829," p. 147, Plate xlv, fig. 2.

‖ "Synopsis des Echinides fossiles," p. 333.

¶ "Fossile Echinodermen," etc., 1869, p. 232.

The finding of *O. corculum* to be an *Echinocorys* naturally raised doubts as to whether Dr. Barrois' fossil was really *C. pillula* or the small gibbous form of *Echinocorys* characteristic of the *Act. quadratus*-zone. Goldfuss's figure is much larger than a normal *C. pillula*, and Desor also says that *pillula* is the size of a hazel nut (*noisette*), whilst *corculum* is that of a walnut (*noix*).[†]

Subsequently to the reading of the paper I took advantage of the presence of Dr. Barrois at the Centenary Celebration of the Geological Society of London to show him specimens of both species, when he unhesitatingly selected the *C. pillula* as being the form he always referred to when using the term *Offaster corculum*.

C. pillula is a very characteristic fossil of the *Act. quadratus*-zone, but the other two fossils mentioned as occurring with it, *M. cor-anguinum* and *E. conicus*, are exceedingly rare in that zone, although common in the *Marsupites*-zone. Having myself found no evidence of the higher zone in Surrey, I am inclined to think that this record of *O. corculum*, if it be not a mistake, is one of those exceedingly rare cases in which *C. pillula* occurs in the *Marsupites*-zone.[‡]

The completion of my systematic examination of the pits near the Tertiary border has proved conclusively that the *Marsupites*-zone, in its strictest sense, does extend throughout the whole length of Surrey, a distance of some thirty-eight miles. Dr. Barrois, therefore, although he did not find a single *Marsupites* plate, nor any other zonal fossil, was right in assigning the uppermost beds to this zone. This is the more remarkable as he relied chiefly on the "peu de silex" for his diagnosis, whereas in my experience this zone in Surrey, and especially in the western portion, contains abundant flint, very much more than it does in Thanet. Dr. Rowe, however, has pointed out that this is more frequently the case than is generally supposed.* It occurs mostly in scattered nodules, not often in definite bands, but with an occasional thin tabular layer. The nodules are generally solid and tough, and very black inside, with a varying thickness of smooth white cortex. The chalk itself is very white and soft.

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[*] D'Orbigny calls it *Echinocorys papillosus*, and gives *Ananchytes corculum* as a synonym. "Pal. Française," 1853, vol. vi, p. 69 and plate 808.

[†] "Synopsis des Echinides fossiles," pp. 332 and 333.

[‡] See Rowe, *Proc. Geol. Assoc.*, vol. xvi, p. 342, and vol. xvii, p. 55.

All the villages between Leatherhead and Guildford are built on the junction of the Tertiaries with the *Marsupites* Chalk, and the southern margin of the zone is roughly indicated by the main road connecting those two towns. All the pits on the north of that road, with two exceptions, are cut in this zone. One of these exceptions, No. 246, lies at the bottom of a small combe, which has cut down to the underlying *M. cor-anguinum*-zone, while close by, No. 245, about 30 ft. higher, yields *Uintacrinus*. In this neighbourhood one may go into pit after pit and find plates of *Marsupites* with almost monotonous regularity, and it is astonishing that they have remained so long unrecorded.

West of Guildford the zone is continued all along the north side of the Hog's Back, but is confined to the gently sloping ground at the foot of the ridge.

In every pit which I have assigned to this zone either *Marsupites* or *Uintacrinus* has been found. The number of sections in the zone is eighteen, which with the twenty-two sections found east of the River Mole makes forty for the whole county.

Zone of Micraster cor-anguinum.

This zone covers most of the wider part of the area east of Guildford, and forms the northern flank of the Hog's Back. Some of the pits are of considerable size, and the characteristic regular lines of nodular flints at frequent intervals are often well displayed. In the higher part of the zone *Conulus albo-galerus* (=*Echinoconus conicus*=*Galerites albo-galerus*) is abundant, and a large proportion are of the small tumid variety.

Zone of Micraster cor-testudinarium.

This zone is not well displayed in this district. I have only found a few sections, and apparently it is thinner here than in east Surrey. Chimney pit (No. 291) is the best exposure, and affords a fair list of fossils. It contains fewer flints than either the zone above or below, and several yellow bands of hard nodular chalk, one of which would appear to be at or near the base of the zone. This can be well seen at Artington pit (No. 299) and Mrs. Sturgess's pit (No. 312A).†

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* *Proc. Geol. Assoc.*, vol. xviii, p. 230.

† Since the above was written Messrs. Chatwin and Withers have described a similar bed at the base of the zone in Oxfordshire. See *ante*, p. 413.

Zone of Holaster planus.

This zone, on the contrary, is seen to great advantage in the district, and is apparently thicker than in many other counties, but its upper limit in many pits is rather difficult to fix. At Williamson's Quarry (No. 295) at Guildford it can hardly be less than 60 ft. in thickness, for, although a platform at the northern end affords access to the upper beds, no definite evidence of the overlying zone was obtained. It is probable that there is here, as at Dover,* a thick passage bed between the two zones.

The Chalk is white and very hard and contains much flint, frequently in courses which approach those of the *M. coranguinum*-zone in regularity, noticeably at the above-named pit and in Echo pit (No. 294). At Monkshatch (No. 312) there are several pockets of very white and very soft powdery chalk, from one of which I obtained a fine but broken specimen of *M. cor-bovis*.

MIDDLE CHALK = *Turonian.*†

Zone of Terebratulina gracilis.‡
Zone of Rhynchonella cuvieri.

LOWER CHALK = *Cénomanian.*

Zone of Holaster subglobosus.
Zone of Ammonites varians.

The outcrop of these two divisions of the Chalk is confined to the face of the escarpment. The individual zones present no abnormal features, and do not require detailed description, but owing to the disturbance of the beds, to be described presently, they occur at varying heights along the escarpment, and in some places the lower zones are entirely concealed.

The Lower Chalk is not, on the whole, such an important feature as it is to the east of the River Mole.

PHYSICAL FEATURES.

FROM THE RIVER MOLE TO THE RIVER WEY.

This eastern portion will be dealt with first. It is triangular in shape, with the towns of Leatherhead, Dorking, and Guildford at the angles.

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* Rowe, *Proc. Geol. Assoc.*, vol. xvi, p. 311.

† Continental writers include the *H. planus*-zone in the *Turonian*.

‡ Zone of *Terebratulina gracilis*.—I must leave to the Palæontologists the settlement of the vexed question of the proper specific name of the type fossil of this zone, and I simply adopt the name used by Dr. Rowe in his series of papers on "The Zones of the White Chalk of the English Coast," published in the *Proceedings of the Geologists' Association*.

The junction with the Tertiary beds on the north is marked by the line of villages which are dotted along the main road between Leatherhead and Guildford. The road does not pass through the villages, but runs a little to the south of them. A number of parallel cross roads pass from the Chalk on to the Tertiaries, and it is on these cross roads that the villages are placed.

A similar but less regular line of villages, nestling under the escarpment, runs from Dorking to Guildford. The parishes in this district are often peculiar in shape, *e.g.*, the parish of Little Bookham is six miles in length, and only from half to quarter mile in width. Mr. Topley has given an interesting account of parishes of this kind, and to his paper the reader is referred for details.*

The ground slopes upward from the Tertiary border towards the escarpment, which naturally forms the highest ground in the district. Its highest point is on Hackhurst Down, 733 ft. O.D., from whence it declines gradually westward. The wider part is largely covered with clay-with-flints, which supports woodlands of considerable extent.

There are several patches of "Sands of Doubtful Age," the largest of which is at Netley Heath.† North-west of the latter an outlier of Woolwich and Reading Beds is shown on the 1-in. map, but little seems to be known of it. Mr. Whitaker refers to it as follows: "North of Netley Heath an outlier [of the Woolwich and Reading Beds (G.W.Y.)] has been mapped by Mr. Polwhele, but I believe it is much hidden by superficial deposits."‡ I have not been able to locate this satisfactorily, and unfortunately pits Nos. 265 and 266, which presumably lie on its borders, are both overgrown.

Owing to the comparatively narrow outcrop, even in this wider portion, the dry valleys, though numerous and deep, are not so conspicuous a feature as they are east of the River Mole. One, however, is of considerable interest.

Polesden Valley commences near Dunley Hill, at about 620 ft. O.D., not far from the crest of the escarpment. At first it runs with the dip, due north, for about a mile, dropping in this distance 180 ft. It then turns sharply due east along the strike for about three miles, winding, with the beautiful curves characteristic of these chalk valleys, past Polesden Lacey, Chapel Hill, and Camilla Lacey. Here it joins the upper end of the gorge of the Mole, just where that river breaches the escarpment, and immediately facing Box Hill. In its easterly course it has a fall of about 60 ft. per mile, and in the last part has a slightly southerly trend, and somewhat against the dip. I am inolined to think there is a small strike-fault here, but have no very definite evidence at present. Just before the railway is reached, a quarter of a mile south of Burford Bridge Station, a shallow pit is being dug in the floor of the valley. It consists of a bed of flints, mostly unworn and retaining their original cortex, embedded in a loose, powdery, chalky matrix, containing also pellety grains of chalk of various sizes. It is exactly the kind of material one would expect to find on the theory suggested in my previous paper that these deeply cut dry-valleys are formed by solution.

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* "On the relation of the Parish Boundaries in the S.E. of England to Great Physical Features, particularly to the Chalk Escarpment," *Journal of the Anthropological Institute*, vol. 3.

† Stebbing, *Proc. Geol. Assoc.*, vol. xvi, p. 524.

‡ *Mem. Geol. Surv. Gt. Britain*, vol. iv, part 1, p. 110. See also H. H. French, *Proc. Geol. Assoc.*, vol. x, p. 183.

Three small but remarkable valleys near Guildford also claim attention. Dean Bottom, Walnut Tree Bottom, and Warren Farm Bottom * occur in rapid succession, and present the same general features. Each is short but deeply cut, and at first runs due west and then sweeps round to the north, leading down to the lower ground of the Tertiaries. I suggest that all these have been excavated by solution along lines of weakness, probably joint-planes, which may have been converted into fault-planes by earth movements. The intervening ridges are each protected by a clay capping In the case of Walnut Tree Bottom the evidence for a slight fault is fairly clear. Chimney pit, No. 291, in the face of the escarpment, shows at the top indications of the base of the *M. cor-anguinum*-zone, while Merrow Downs pit, No. 284A, on the north side of the axis of this valley, and therefore at a presumably higher horizon, is shown by its fossils to be in the *M. cor-testudinarium*-zone. This suggests a down-throw to the south.

A deep hollow, anvil-shaped in plan, is seen in the face of the escarpment at Colekitchen Hole, near Gomshall. It is surrounded by precipitous slopes 200 ft. high, but deep as it is, it does not breach the crest of the escarpment, although a dry valley (Honeysuckle Bottom) runs up the dip-slope towards it, and the ridge of ground, over 600 ft. O.D., separating them is under 100 yards in width. The "Hole" is possibly due to a prolongation of the Rookery fault at Wotton. This fault marks a change in the direction of the strike of the escarpment, which, from here westward to Farnham, is practically east and west, but east of this point it takes a decided northerly trend. Another deep hollow is to be seen at Pickett's Hole, two miles east of Colekitchen Hole.

Westward of Colekitchen Hole the height of the escarpment gradually diminishes. The 600 ft. contour line is passed opposite Albury, the 500 ft. opposite St. Martha's Chapel, the 400 ft. opposite The Chantries, until at Pewley Hill, the eastern portal of the gorge of the Wey, it is but 375 ft. O.D.

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* There are three "Warren" Farms in this district. One is near Horsley Towers, and two are close to Guildford, one of these being on the Lower Chalk, near The Chantries, and the other on the Upper Chalk, near the Golf House. The last named is the one referred to above.

A narrow strip of Selbornian (Upper Greensand and Gault) runs along the foot of the Chalk escarpment, occupying the floor of the narrow, waterless valley between the Chalk and the parallel ridge of Folkestone Sands. The Tillingbourne rises on the north bank of Leith Hill, turns sharply westward at Wotton, and runs over the Sandgate beds to join the River Wey at Guildford, but does not enter this Selbornian valley in any part of its course.

GUILDFORD DISTRICT.

In the neighbourhood of Guildford there is abundant evidence of violent disturbance. South of the town a sharp anticline brings up the Weald Clay at Peasemarsh, and the outcrop of the whole of the beds between the Tertiaries and the Wealden measures only 1¾ miles, so the average northerly dip must be considerable. It is, however, by no means uniform, that of the Upper and Middle Chalk not exceeding 10°, while that of the Lower Chalk, Selbornian, and Lower Greensand is much greater.

As long ago as 1875,* Mr. Topley suggested that most of the rivers which escape from the Weald through breaches in the Chalk escarpment run in gentle transverse synclinals. He does not quote the Wey as an example, but apparently it is a case in point, for west of White Lane pit (No. 287), near St. Martha's Chapel, the strata dip noticeably to the west. At this pit the 400 ft. contour line marks the top of the *R. cuvieri*-zone, while at Rifle pit, Guildford (No. 295A), the top of the zone is only about 150 ft. O.D., a fall of 250 ft. in the intervening two miles.

The coincidence of the above-mentioned gentle transverse syncline with the strong longitudinal anticline at Peasemarsh has produced a sharp twisting of the strata, the tension of which has been relieved by a strike-fault, with its downthrow on the north, which runs along the foot of the escarpment for some four miles to Silent Pool, when it is probably cut off by the Albury fault shown on the 1 in. map. The spring which feeds Silent Pool may possibly arise at the junction of the two. On the north side of this fault the strata dips northwards at gentle angles, while on the south side they are highly inclined. The gentle dip can be seen in most of the pits in the higher part of the scarp face, particularly Echo pit, No. 294, and Williamson's Quarry, No. 295, while the high dips can be well studied at Warren Farm pit, No. 290, and Albury Downs pit, No. 286. The Folkestone Sands of the Lower Greensand are also highly inclined, as may be seen at The Chantries, St. Martha's Hill, and near Albury. The result is that very little of the Lower Chalk is exposed in this neighbourhood. I venture to name this the Chantries fault.† (See Fig. 32.)

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* "Geology of the Weald, 1875," *Mem. Geol. Survey*, p. 276.

† See *ante*, p. 174.

This fault is within the mass of the Chalk itself, and the floor of the valley has been excavated along its course and not along the outcrop of the Gault, where one might expect to find it. This is proved by the position of Warren Farm pit, No. 290, which is on the south flank of the valley separating the Chalk escarpment from the Lower Greensand of The Chantries.

THE HOG'S BACK.

The Hog's Back is a bold ridge of chalk running due east from Guildford to Whiteways End near Farnham, about 8 miles. The highest point, 503 ft. O.D., is near Monkshatch, but the top is practically level for several miles. The average height above the surrounding country is only about 200 ft., but the isolated position of the ridge and the steepness of the slopes on either side make it a very prominent feature in the landscape. The crest is surprisingly narrow, scarcely more than the width of the roadway which traverses its whole length, and affords fine views over the surrounding country. Between Whiteways End and Farnham (2 miles) the Chalk becomes a very subordinate feature.

The Chalk outcrop along the Hog's Back has an average width of about half a mile, and, as everyone knows, the narrowness is due to the high angle of dip, and to the subaërial denudation which has removed the relatively softer beds on both sides, leaving the Chalk upstanding as a ridge. Detailed examination, however, has revealed an unexpectedly complicated structure.

West of Guildford the axis of elevation seems to have been shifted slightly to the north, so that the Peasemarsh anticline and its accompanying Chantries fault die out, and are replaced by an elevation of the Chalk itself. Therefore as we go west we find the dip of the beds gradually increasing, eventually reaching 60° or even more, with distinct evidence of over-thrusting in places. Starting from Guildford, where it is about 8°, the dip has risen to about 25° at Artington pit, No. 299, and is about the same at Monkshatch, No. 312. Beyond Wanborough it rises rapidly to 50° at Inwoodbarn, No. 314, and 60° or more at Seale Lime Works, No. 317. This rise of the beds allows the Lower Chalk to reappear in the face of the escarpment, and we first find it at Down Lane pit (No. 302) at 325 ft. O.D., from whence it rises westward until at Seale its top is nearly 400 ft. O.D.* At Tongham Lane pit, No. 324, one mile from Seale we have evidence of compression. Here the dip is less at the north end (about 45°) than at the south end, where the beds are contorted and almost vertical. Three quarters of a mile farther west, at Whiteways End pit, No. 325, the compression is still greater and suggests overthrusting and faulting, for here the Upper

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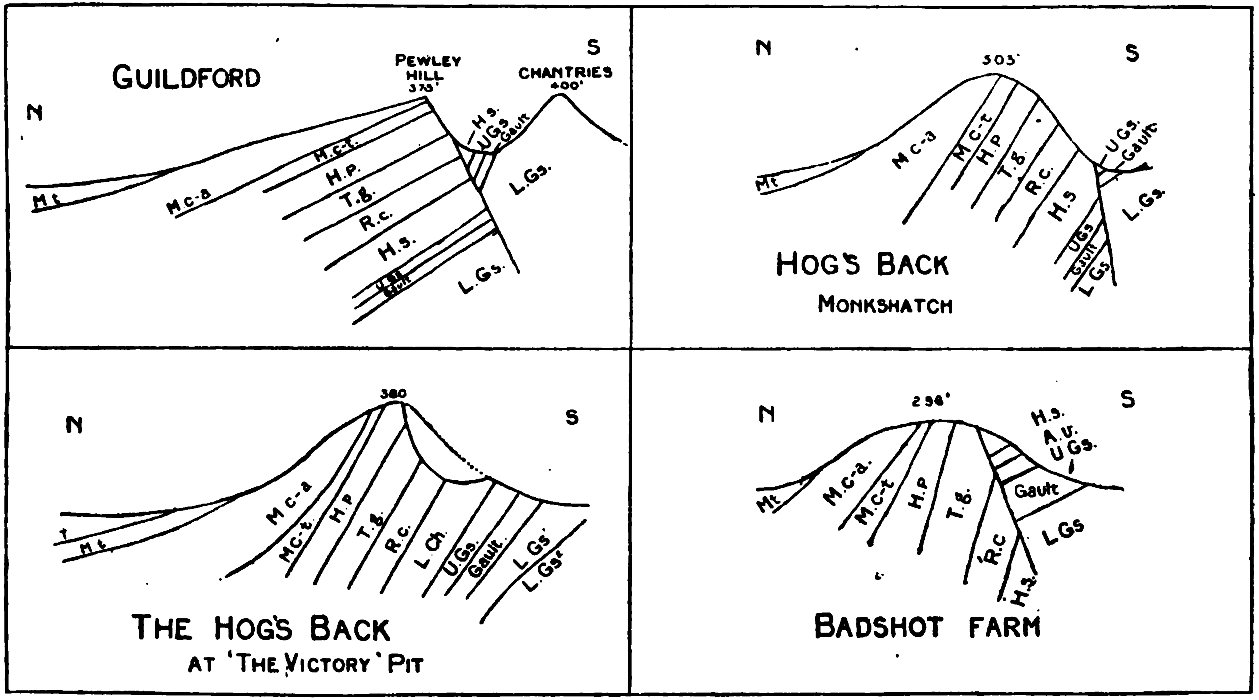
* See also *postea* p. 449.

FIG. 32. A.—SECTION AT GUILDFORD, A LITTLE EAST OF RIVER WEY.

B.—SECTION ACROSS HOG'S BACK, 3½ MILES WEST OF GUILDFORD.



C.—SECTION ACROSS HOG'S BACK, NEAR TONGHAM LANE, 3½ MILES WEST OF B.

D.—SECTION ACROSS THE "ISLAND" OF CHALK BETWEEN THE DIP FAULTS AT RUNFOLD AND BOURNE MILL.

Greensand* is separated by only 250 ft. from the *Holaster planus*-zone. (See Fig. 32.)

At Runfold a fault occurs, first noticed by Mr. Long in 1837. The Chalk ridge is thrust northward, and I am inclined to think the displacement is rather greater than is shown on the 1 inch map, so that the Selbornian abuts directly against the Tertiaries. Through the gap runs the railway from Guildford to Farnham. Still nearer to Farnham, there is another small fault, not marked on the map, the course of which runs along the low ground on the east of Farnham where the gap in the chalk ridge is much wider than at Runfold. In this gap lies the Farnham Sewage Farm, close to which a strong spring emerges at the base of a small chalk bluff.

This is the source of the Bourne Mill stream, and I suggest that the spring marks the position of this second fault. At this point the strike of the beds, until now practically due east, takes on a strong southerly trend, which is well indicated by the direction of the avenue in Farnham Park.

Here the Chalk abuts against the Gault, which appears on the opposite side of the stream, while the disrupted Chalk appears a short distance away to the north-west, at the corner of Farnham Park.†

Between these two parallel faults there is a small "island" of chalk, the structure of which is, fortunately, well displayed at Badshot Farm pits (see map, Fig. 33.). The north pit, No. 326, shows a dip of about 40° and is cut in the zone of *Micraster cor-anguinum*. The south pit, No. 327, 60 yards away, is more complicated. At the extreme north end there is highly flinty chalk dipping at about 45°. This is cut off by a thrust plane and succeeded by flintless chalk with a dip of 75°. This flintless chalk is hard and creamy, with two distinct marl-bands and some vein-calcite. The violence of the disturbance is evidenced by the state of the flints, which are completely shattered and fall into hundreds of pieces at a touch. Some are drawn out into curved lines resembling coal dust, just like those mentioned by Dr. Strahan as occurring in the region of the Isle of Purbeck thrust-plane. As is frequently the case in highly disturbed strata these beds yield no fossils. The lower part of the pit shows similar flintless chalk with a slightly smaller dip, about 55°, but the zone was proved to be that of *Terebratulina gracilis* by the finding of several of the name-fossils. The other fossils found were *Terebratula* (*? semiglobosa*), *Rhynchonella cuvieri*, *Porosphæra globularis*, *Ostrea*, *Inoceramus*, *Cidaris*, and *Ptychodus*. In its turn this flintless white chalk is cut off by a strike fault, leading to the south, which brings up the grey chalk of the *Holaster*

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* Jukes-Browne (*op. cit.*), Vol. II, p. 52.

† A large sheet of gravel occurs here which has been separated into two portions by the Bourne Mill stream. The western portion is wholly on Gault, but the eastern is partly on Chalk and it is thus evidently of later age than the fault.

subglobosus-zone, succeeded by Chalk Marl, Chloritic Marl, and Upper Greensand. The fossils found in this grey chalk were *Rhynchonella martini*, *R. mantelliániana*, *Kingena lima*, *Terebratula squamosa*, *T. semiglobosa*, *Pecten orbicularis*, *Nautilus deslongchampsianus*, and *Turrilites scheuchzerianus*. This is quite a typical Lower Chalk fauna. (See Fig. 32.)

As the whole of the *R. cuvieri*-zone and nearly all the *H. subglobosus*-zone is cut out, this fault must have a throw of not less than 150 feet and most probably more. The fault plane is quite visible owing to the contrast in colour and the smaller dip of the lower beds (about 35°). This strike fault is evidently the same as the one inferred at Whiteways End and its displacement by the Runfold dip fault proves the latter to be the younger of the two.

FARNHAM.

At Farnham the chalk ceases to be the dominant feature of the landscape. For a short distance the Tertiaries become of importance, and form a plateau, known by the various names of Hungry Hill, Cæsar's Camp, Farnham Beacon, and Lawday House, which rises to a height of over 600 ft. O.D. This lofty elevation, however, is quite local, partly due to a thick capping of "plateau gravel," and a little to the west they resume their normal insignificance, and then the Upper Greensand comes into prominence.

West of the Park the Reading clay crowns the chalk escarpment without any surface feature at the junction, and this is succeeded, as the ground rises northward, by London Clay, and ultimately by Bagshot beds. In the Park itself a short valley has been excavated between the Chalk and the Tertiaries, (rather below the actual junction), but the latter form all the higher ground and overlook the low chalk ridge on which the fine avenue of trees is situated. Farnham Castle stands on the root of this ridge just where it merges into the main scarp, so that the approach to the Castle from the north-west must always have been easy, in a military sense.

The outcrop of the Chalk is thus confined to the face of the scarp, and is not more than a quarter of a mile in width, and 100 ft. in vertical height, its base being proved by the presence of Chalk Marl at Hop Field pit (No. 329). This is strong presumptive evidence of the Badshot strike-fault being continued past Farnham. Unfortunately there are but few pits in the immediate neighbourhood, and the exact relations of the beds are difficult to understand. The highest zone exposed is that of *T. gracilis* at Claypit Gully pit, No. 330, where the dip is about 45 degrees. With a narrow outcrop and high dip the conditions are the same as along the Hog's Back, but instead of the Tertiaries forming low ground at the foot of a ridge, they form the highest ground of the district, rising to over 200 ft. above the highest chalk. The difficulty of interpretation is enhanced by the fact that a little farther west the chalk outcrop suddenly widens to more than two miles at Crondall, and as most of this broad expanse belongs to the *Marsupites*-zone,* with Tertiary outliers at Horsedown Common and Well, the dip is presumably low.

There are already two sections† of the Farnham district in our PROCEEDINGS, and although they differ considerably in detail neither shows any sign of a fault, but I venture to suggest that such a twisting of the beds as is implied by so sudden a change of dip and strike would most probably be accompanied by considerable faulting.

The south-east of England is not generally regarded as an area of violent disturbance, and some may be inclined to think that the extensive system of faulting just described is exaggerated. But it must be remembered that in this district the conditions are exceptional. The width of the Chalk outcrop along the Hog's Back is so very much narrower than that at either end that we ought to expect something unusual to have happened to the stratigraphy. Outside the Isles of Wight and Purbeck no district shows so narrow an outcrop of Chalk as this. It is true that the thickness here is not so great as in those places, but on the other hand the average dip is not nearly so high. Unlike the Isle of Wight, where the highest dips occur in the highest beds, here the highest dips mostly occur in the lowest beds. Though the Chalk is not a hard rock neither is it a plastic one, and the strong joints which traverse it provide lines of weakness along which displacement of the strata could easily be effected. Even in the very slightly disturbed area farther east small faults and reversed dips are not uncommon, as Mr. Evans has recorded in describing the Croydon-Oxtead section.

All the evidence points to the conclusion that the Hog's Back movement took place at a comparatively recent period, long subsequent to the general elevation of the Weald, and after denudation had laid bare a large area of the Lower Cretaceous beds. Its situation in the extreme north-west corner of the Weald shows that it is quite unconnected with the general Wealden uplift, as there the latter is dying away beneath the broad unbroken Chalk arch which divides the London from the Hampshire Basin. At first the displacement was longitudinal, producing rising of the beds and movement along one or more thrust-planes, and causing the strike-fault seen at Badshot Farm pits, but the upheaval still continuing, subsequently fractured the mass transversely and thrust the Chalk northward along the dip-fault-planes at Runfold and Bourne Mill. Probably when the

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* Treacher and White, *Proc. Geol. Assoc.*, vol. xix, 1906, p. 378.

† *Proc. Geol. Assoc.*, vol. xiii, 1893, pp. 75 and 79.

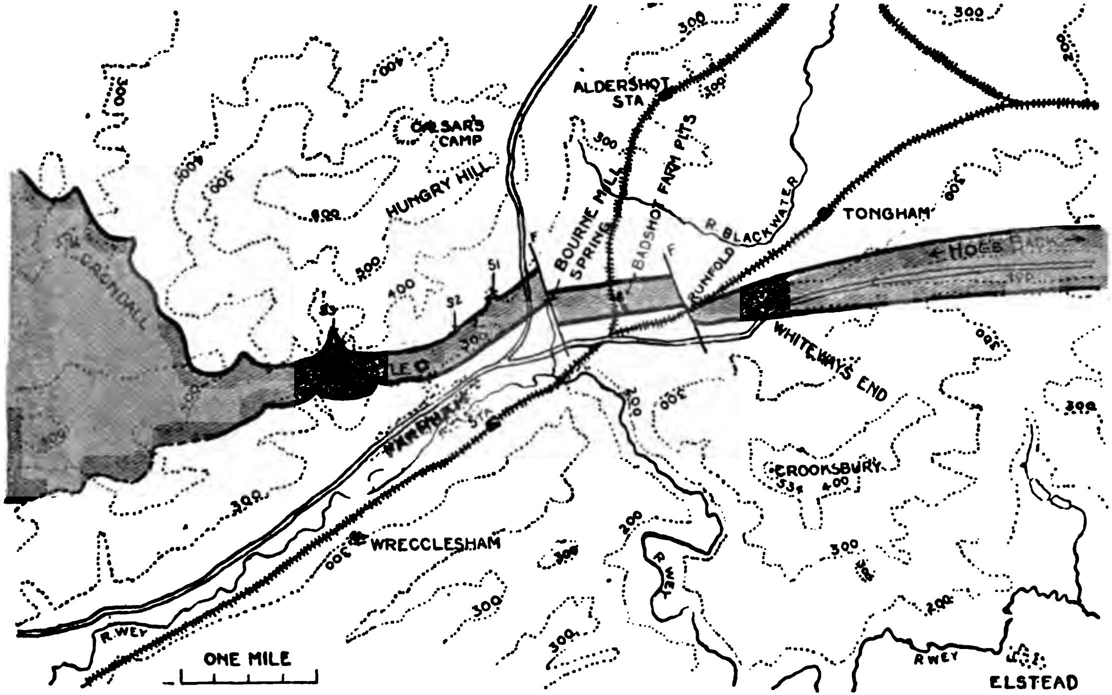

FIG. 33.—SKETCH MAP OF FARNHAM DISTRICT.

The shaded portion is Chalk. The strike-fault is close to the southern edge of the outcrop. F.F. Faults. S1, S2, Swallow holes in Farnham Park. S3, Swallow hole in Clay-pit Gully.

Hog's Back uplift took place the escarpment had been already cut back to nearly its present position, and the upper waters of the Wey may have formed part of the Blackwater system, escaping from the Weald through the breach in the Chalk at Farnham. The wide-spread sheets of gravel bordering the Blackwater, composed of flints and Lower Greensand materials, imply the former existence of a considerable river, whereas now not a single drop of water passes.

THE FARNHAM SWALLOW HOLES.

Another interesting phenomenon, which helps to accentuate the abnormal physical character of the district, can be well studied at Farnham.

Several small streams run off the higher ground of the Tertiary clays until they reach the Chalk, when they disappear down a swallow hole. Usually the whole flow is absorbed, but after heavy rain the "swallet" cannot always cope with the increased quantity, and then the surplus water flows away down a definite overflow channel, the gravelly bed of which is quite dry at other seasons. The local name for these swallow holes is the very appropriate one of "soakage."

Seventy years ago an account of these was read before the Geological Society by Mr. George Long, of which only an abstract was published.* By the kindness of the authorities of the Geological Society I have been allowed to inspect Mr. Long's original manuscript, but the following account is based on my own observations.

The swallow holes number seven in all, the two in Farnham Park and the one in Claypit Gully being the most interesting. The two former are situated on the north flank of the short valley already described. The eastern and larger is at the lower end where it opens out into the low ground near Hale. The stream which enters it is formed by the union of several small ditches which carry off the surface water of the larger portion of Farnham Park. The main stream has, on a small scale, a very meandering course, with sharply-cut clay banks, and near the spot where it disappears, bright red mottled clay of the Reading series can be clearly seen in its bed. The actual swallet is a marshy area, overgrown with nettles and enclosed with railings.

The swallet consists of a cluster of holes or fissures down which the water soaks, and therefore its disappearance is not so imposing as one might expect from Mr. Long's account (which says they "plunge into the ground!"), but there is generally a small whirlpool formed at each hole. The "storm-water" gully, at first underground, suddenly appears about

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* *Proc. Geol. Soc.*, vol. iii, p. 101.

30 yards lower down the valley, its bed, usually quite dry, being strewn with many flints. This gully eventually leads into the Bourne Mill stream a little below the source of the latter.

Mr. Long, in the abstract before referred to, says, "The water absorbed by the holes in Farnham Park is supposed to reappear at the Bourne Mill stream," but he himself doubts this, for he adds, "and though soft where it sinks into the chalk it is hard and unfit for use where it again breaks forth." In the manuscript, moreover, he gives further reasons for thinking that the supposition is not correct. Certainly on each of my visits the quantity of water emerging at the spring has been far greater than that which was being absorbed at the swallow-holes, and it is evident the supply is not dependent on that source alone. On the other hand, if, as I suggest, the Bourne Mill spring rises in a fault-plane, it is possible that part at least of this water does come from the swallow-holes. The size of the valleys which these smal streams have excavated shows that the quantity of clay carried off in suspension is enormous, and one would have expected the absorbing fissures to have been filled up long ago unless there was some outlet near at hand. Moreover, the beds themselves seem to dip in that direction.

The other swallow hole in the park is close to the path leading to Upper Hale, just where it commences to rise past the central enclosure. The hollow is deep and cup-shaped, and a large oak tree is growing in it. The stream is very small, and is all absorbed, there being no overflow channel. A third stream is absorbed just outside the park palings skirting the Odiham Road, and in this case an ill-defined overflow channel is beginning to be formed.

Claypit Gully lies in a bifurcated valley, which, although short, is deeply cut, with sides that are remarkably steep considering that they are of clay. Just where the water disappears there has been some recent slipping, which temporarily interfered with the proper working of the swallow and caused a slight overflow. The disappearance of the water is not well shown at present, but the soaking away can be distinctly heard. The overflow channel is well marked; it is about 6 ft. in width and over 4 ft. in depth, with a gravelly bed. It crosses the whole width of the chalk as a dry gully, eventually joining a permanent stream which is fed by springs thrown out at the outcrop of the Gault. This runs across the Gault on to the Lower Greensand and falls into the River Wey at Cox Bridge, about a mile west of Farnham.

Swallow holes of this nature are not unknown in other districts, but in such cases the dip of the Chalk is usually very low, whilst the Tertiary or other clay beds above form a gentle slope of the nature of an escarpment. Mr. Whitaker gave a list of those occurring in the London Basin in his evidence before the

Royal Commission on Metropolitan Water Supply in 1893[*] and in explaining the diagram illustrating their mode of origin expressly states that there would be a wide expanse of Chalk on account of the low dip. This increases the abnormality of the Farnham district, where the dip is high and the outcrop very narrow.

CONCLUSION.

It will be noticed that I have not attempted to give the thickness of the different zones. If the various typical fossils were rigidly confined to their proper zones the task of determining the exact limits of a zone might be overcome by careful collecting, although in comparatively few cases is the whole of a zone exposed in any one pit, and even then the upper limit is generally inaccessible. But everyone knows that the typical fossils are not rigidly confined to their own zone, and there is rarely a hard and fast line of demarcation. Between them are passage beds; beds in which there is not only an intermingling of the faunas of the two zones concerned, but the fossils themselves are passage forms. For instance, in such a transitional bed it is by no means rare to find examples of *Micraster* with one surface showing the characteristic features of one zone, and the other surface displaying the characteristic features of the succeeding zone. And this, indeed, is exactly what the whole theory of evolution teaches us to expect. Therefore, by excluding or including these passage beds, two different observers might assign quite a different thickness to the zone in question.

As to the thickness of the Chalk as a whole I have no evidence to offer beyond what is already known by the boring at East Horsley, which shows a thickness of 817½ feet. This is much thicker than in any other boring in the London basin, and is most probably due to real thickening of the beds, as the dip at East Horsley is not high enough to make any material difference in the result. Mr. Jukes-Browne, in the course of a discussion of my previous paper,[†] very truly points out that this would be quite sufficient to allow of the *M. cor-anguinum*-zone being more like its usual thickness than it is near Croydon. Unfortunately no other boring in the district goes through the whole of the Chalk into the beds beneath. The boring at Winkfield, where the Chalk is 725 feet thick, is too far away and too near the northern outcrop to be of service to us in estimating the thickness near Farnham.

This attempt at a complete zonal survey of the Surrey Chalk must not be regarded in any way as the final word on the subject, and I hope it may be the means of inducing others to take up the work and check my results. The task of zoning so large a number of pits by an amateur with but little leisure is no light one, and it would be strange indeed if mistakes have not been made. In some cases the evidence on which I have zoned a pit may have been too scanty, and additional collecting may show a need of revision, but I believe that my conclusions as a whole will be found substantially correct.

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[*] *Report Roy. Com. Met. Water Supply*, 1893, *Appendix No. C.* 49, p. 433.

[†] *Proc. Geol. Assoc.*, vol. xix (1906), pp. 288, 289.

Finally, I have to tender my most cordial thanks to the numerous land-owners, farmers, and quarry-owners who have given me permission to examine their pits; to the following gentlemen for help and encouragement in various ways: Mr. H. A. Allen, Dr. F. A. Bather, Mr. G. E. Dibley, Mr. W. D. Lang, Mr. E. T. Newton, Mr. C. D. Sherborn; to Mr. W. P. Young, who took all the photographs and made all the lantern slides used in illustrating the reading of the paper; to Dr. A. W. Rowe, who has been ever ready to identify specimens and explain difficult points; and lastly to Messrs. W. Johnson and W. Wright, who have given unceasing help and companionship in the field, either the one or the other having accompanied me on nearly every occasion.

A LIST OF CHALK PITS IN SURREY, WEST OF THE RIVER MOLE.

The numbers of the pits follow on from those given in my paper on the Chalk Area of North-East Surrey (PROCEEDINGS, Vol. XIX, p. 200). The figures in brackets are the approximate heights above the ordnance datum.

ABBREVIATIONS OF ZONAL TITLES USED IN THE TEXT AND DIAGRAMS.

M.t. = *Marsupites testudinarius.*
U. = The sub-zone of *Uintacrinus* of the *Marsupites*-zone.
C.a. = *Micraster cor-anguinum* (M.c.a. in the diagrams)
C.t. = *Micraster cor-testudinarium* (M.c.t. in the diagrams).
H.p. = *Holaster planus.*
T.g. = *Terebratulina gracilis.*
R.c. = *Rhynchonella cuvieri.*
H.s. = *Holaster subglobosus.*
A.v. = *Ammonites varians*=Chalk Marl (included in H.s. in most of the diagrams).

SHEET 25 N.E. OF THE 6-IN. MAP. MICKLEHAM DISTRICT.

No.

196 (230′). At Park Farm, Fetcham. Very small exposure.

197 (190-220′). Hawkshill pit. Chalk white, with numerous flints. A strong tabular is shown abruptly ending at a dip fault. Fossils not plentiful, but quite characteristic of zone. *Synhelia* found. [C.a.]

198. (140-170′). Ice House pit, Norbury Park, close to River Mole. Tough clayey chalk, strongly veined with dark grey marl; numerous flints with thick, dull earthy cortex. [H.p.]

(*Nos.* 199 *to* 201 *E. of River Mole.*)

SHEET NO. 25 S.E. BOX HILL DISTRICT.

202 (470′). N. of Crabtree Cottages. Shallow, overgrown,

202*a* (460′). Near 202, in Norbury Park. Very small. [? C.a.]

203 (220-270′). Chapel Lane pit near Camilla Lacey. Very old deep pit, large rough talus, main face in dangerous condition. Chalk and flints of upper part resemble No. 198; lower part more marly. Fossils few, but *S. spinosus* relatively abundant. [T.g. : H.p.]

204 (220′). In field quarter mile south of Camilla Lacey. Old and overgrown.

205 (260-320′). Dorking Lime Works. A group of large old pits; have been worked over 200 years. Face about 60 ft. *A. plenus* marl band present ("Soap"). [H.s : R.c.]

206 (320′). A little E. of No. 205. Abandoned.

(*Nos.* 207 *to* 235 *E. of River Mole.*)

SHEET NO. 25 N.W. BOOKHAM.

236A (350′). Hale pit, near Ralph's Cross. Old and full of trees.

237A (220′). Eastwick pit, Great Bookham. A large old pit, very little used and partly overgrown. Flints few; fossils most numerous in upper part. [M.t.]

238 (225′). Near Bookham Grove, in private ground. Full of trees.

239 (225′). At the Grange, Little Bookham. Large, but disused many years. No exposure.

240 (280′). Rectory pits, Little Bookham. Chalk strongly jointed, with horizontally slickensided faces showing N. and S. movement. Many flints, mostly in courses. [C.a.]

241 (250′). In grounds of Manor House. Full of trees.

242 (250′). In grounds of Effingham Lodge. A large pit only occasionally worked. Chalk white and soft, scattered flints numerous. [M.t.]

No.

242A (265′). In grounds of Effingham Lodge, 300 yards S. of No. 242. Here the dip of the beds has brought up the *Uintacrinus*-band. Very small. [U.]

243 (250′). At Home Farm, Effingham. Disused; full of trees.

244 (230′). At Orestan Farm. Medium size; full of shrubby trees; small exposure; many flints. [M.t.]

245 (340′). On Standard Hill. Small, full of rubbish; flints few; chalk much iron-stained. [U.]

246 (310′). Warren Farm Pit, Effingham, quarter mile S.W. of No. 245, in shallow valley, which has cut down to the underlying zone. Chalk rather hard, thick bedded with flints. Fossils scarce. [C.a.]

247 (300′). Smuggler's Hole pit, Horsley Towers. Very large, but disused nearly 100 years. A small, dirty exposure right at top yielded *Marsupites*. [M.t.]

248 (300′) North
248A (300′) Middle } In Park Wood, Horsley Towers.
249 (330′) South On western flank of narrow ridge of Eocene beds. All much obscured.

249A (330′). Dancing pit, Horsley Towers (at S.E. corner of Sheet 24 N.E.). Very old large pit. Only a few square feet exposed, in which *Marsupites* and sub-pyramidal *Echinocorys* were found. [M.t.]

SHEET 25 S.W. RANMORE DISTRICT.

250 (420-450′). At Phœnice Farm, Norbury Park. Very old pit. Large exposure, but dirty and moss-grown. Massive chalk, many flints, some with bright pink cortex. Few fossils, *Actinocamax verus*. [C.a.]

251 (300-380′). Milton Court pit. In face of escarpment south of Ranmore Church. Very old, nearly 100 ft. deep; full of trees; large talus. [H.s.: R.c.]

251A (410-450′). In Yew Tree Lane, Polesden Lacey. A roadside section running up the flank of valley; junctions obscure. [H.p. (?): C.t.: C.a.]

252 (460′). Yew Tree Farm. A small pit on opposite side of valley, capped with clay-with-flints, chalk white and hard, some large flints, no fossils.
Between the last two sections a well has been sunk in the floor of the valley, but the fossils on the spoil heap are, of course, of no zonal value.

253 (510′). At Pigdon. Small and grassed over.

254 (370-470′). Coomb pit. In lower part of scarp face. Very old, huge talus yielding R.c. zone fossils. At base on E. side grey chalk is seen. [H.s.: R.c.]

No.
255 (600′). In Critten Lane, near Dunley Hill. Large pit, now disused and badly weathered. Rather hard white chalk, fossils scarce. [(?) C.a.]

SHEET 33 N.W. WOTTON DISTRICT.

255A (400′). Pickett's Hole is a cup-shaped hollow, fully 350 ft. deep, cut in the face of the scarp about 2½ miles W. of Dorking. The crest is here 700 ft. O.D. A small pit near bottom, on 400 ft. contour, yielded chalk marl fossils. [A.v.: H.s.]
256 (410′). At foot of White Down, two small pits, lower one shows small section of grey chalk. [H.s.]
257 (690′). Quarter mile W. of No. 256. Small deep pit, full of trees.
258 (650′). In Dunley Wood. Large pit, but full of trees and undergrowth.
259 (480-500′). Dunley Wood lower pit. Small, nearly at base of scarp. Grey chalk with a marl band. [H.s.]
260 (480′). A long trench-like pit a little to W. of 259, and at same level. 300 yards to S. is a large brickfield in the Gault, and a sandpit in the Folkestone Sands, the sections being separated merely by the S.E.R. track. Close by is the granite cross marking the spot where Bishop Wilberforce was killed in 1873. [H.s.]

SHEET 24 S.E. HORSLEY DISTRICT.

261 (400′). Rowbarns pit, West Horsley. Large pit about 30 ft. deep. Chalk white and rather soft, with numerous flints, and a sponge-bed 9 in. thick with a strong nodular flint band 1 ft. above it. Fossils not plentiful but characteristic of zone. [C.a.]
262 (315′). Pole pit. On main road quarter mile E. of West Horsley Church. Old and much overgrown. Fossils few, flints numerous. [M.t.]
263 (280′). Quarter mile W. of West Horsley Church. Overgrown.
263A (300′). Wix Farm pit, West Horsley. Old and much overgrown but with small dirty exposure. Flints numerous. [M.t.]
264 (300-360′). Coombs pit, West Horsley. Fine pit with good exposure. Fossils not abundant, but typical of zone. Well marked bedding planes, strongly jointed with flints in courses at varying intervals. [C.a.]
265 (680′). N.W. of Woodcote Lodge. Small, full of trees.

No.
266 (640′). 300 yds. S. of No. 265. Small, full of trees.
267 (300′). On main road, near Fuller's Farm. Small and shallow, grassed over.
268 (350′). Downs House pit, East Clandon. Shallow, not much used. Chalk white, with a bed of hard unfossiliferous yellow nodular chalk. *Micraster* rare, *Conulus* common. [C.a.]
269 (620′). In Staple Lane. Rather large but old and mostly overgrown. [C.a.]
270 (290′). In main road at East Clandon. Large pit, but quite full of trees and undergrowth.

SHEET 32 N.E. SHERE AND GOMSHALL DISTRICT.

271 (600-650′). On Hackhurst Down in face of scarp. Large old pit, disused. Large talus. Chalk hard, lower part marly and flintless; upper part with many flints and large size *Terebratula semiglobosa.* [T.g. : H.p.]
271A (450′). A small pit 150 ft. below the preceding shows junction of lower and middle chalk with marl band 1 ft. thick yielding *Actinocamax plenus.* [H.s. : R.c.]
272 (480′). 200 yards S.E. of No. 271. Very old, full of trees.
273 (450′). In Beggars Lane, quarter mile W. of No. 271A. Very hard white chalk, no flints. *Inoceramus mytiloides* abundant, other fossils scarce; *Cardiaster pygmæus* found. [R.c.]
274 (400′). At Kingswood Hangers. Very small, disused, grey chalk with strong vertical joints. [H.s.]
275 (530-580′). Near Colekitchen Farm. Very large workings, but long abandoned. Large rubbly talus. [R.c. : T.g.]
276 (500′). At Netley Plantation. Two old pits in thick wood. Large talus. [T.g. : H.p.]
277 (500′). Sherborne pit, above Silent Pool. Chalk of unequal hardness. Scattered nodular flints numerous; fossils plentiful. The abundant *Micrasters* mostly indicate the top of *H. planus*-zone, with passage forms merging into *M. cor-testudinarium*-zone type. *Pentacrinus* found. [H.p.]
277A (350′). Very small path-side section 150 ft. below the preceding. Marly, flintless chalk. [? T.g.]
278 (480-540′). Opposite Juniper Hill, Shere. Large, very old pit; no exposure, but large rubbly talus, with many flints. *Pentacrinus.* [H.p.]
279 (370′). N. of Medlands Farm, Small. Chalk white and hard, flintless, and nodular in places. [R.c.]
280 (400′). At E. end of Albury Down, by side of road. Dull white, tough, flintless chalk. [T.g.]

Sheet 24 S.W. Merrow District.

No.

281 (280′). West Clandon pit. Old, but now being worked again. Chalk very white and soft with abundant flints. Junction of *M.* and *U.* bands is about half way up the S. face. *Actinocamax verus*, *Terebratulina rowei.* [U. : M.t.]

281A (300′). Clandon Rifle pit. Separated from the preceding by a footpath only. Very old; about 70 ft. deep, with large talus, now used as rifle range. Gentle dip to N. On the east side there is a scattered band of *Echinocorys* (mostly broken), reminding one of the similar band at base of *Marsupites* band at Margate. [M.t.]

282 (400′). Roadside section overlooking Dean Bottom. Flints abundant, in courses and scattered. *Micraster* numerous. [C.a.]

282A (500′). Newlands House pit. One-third mile S. of No. 282. Chalk very white. [C.a.]

283 (260′). In Clandon Park. Two very large old pits. Full of trees.

284 (400′). On Merrow Golf Links. Old and grassed over.

284A (400′). Merrow Downs pit, overlooking Walnut Tree Bottom, not marked on 6-in. map. Small and disused, but with fair exposure. Chalk rather soft, many scattered flints and two distinct bands 6 in. apart. *Micraster præcursor* of C.t. type numerous, but mostly crushed. Dip about 5 degrees N. [C.t.]

285 (230′). At Pit Farm. Disused. Now a fowl run.

285A (230′). At Box Grove House. Old, full of trees.

285B (230′). At Merrow Grange. Old, full of trees.

Sheet 32 N.W. Chilworth District.

286 (360′). Albury Downs Pit. At base of scarp under Newlands Corner. Base is of massive grey chalk with band of *A. plenus* marl dipping at about 30° N. Above this is yellowish nodular chalk, much shattered, with *R. cuvieri*-zone fauna. [H.s. : R.c.]

287 (400′). Near Whitelane Cottage. Very hard nodular chalk. [R.c.]

287A (430′). Close to 287. Very small road side section. [T.g.]

288 (320′). N. of Tyting Farm. Small, overgrown.

289 (360′). Quarter mile W. of No. 288. Deep circular pit, full of trees.

290 (220′). One-sixth mile W. of Warren Farm. Close to the Lower Greensand of the Chantries. A long, deep narrow pit showing grey chalk dipping at high angle.* [A.v. : H.s.]

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* For Nos. 290, 291, 292, 294, 295 see also *ante*, p. 174.

No.

291 (300-350′). "Chimney" pit, on Pewsey Hill, Guildford. Large pit near crest of scarp. About 10 ft. from top is a strong orange nodular band. About half-way up is a hard band with many Polyzoa. [H.p.: C.t.: C.a.]

SHEET 23 S.E. GUILDFORD, NORTH.

292 (170′). In York Road, near London Road Station. A large disused pit. Chalk white and soft with many scattered flints. Dip about 10° N. *Marsupites* common and mostly well ornamented, *Actinocamax granulatus*, *Micraster* rare. [M.t.]

293 (130-190′). At Guildford Railway Station. Lower part alone accessible. Chalk white with many regular lines of flints. Dip about 12° N. [C.a.]

SHEET 31 N.E. GUILDFORD, SOUTH.

294 (240-320′). Echo Pit, on Pewsey Hill. Large picturesque pit. Massive, well bedded chalk with many flint courses and a few feet of flintless chalk at the base. Dip very gentle. *Micraster cor-bovis*, large *Terebratula semiglobosa*, *Cyphosoma radiatum*, etc. [T.g.: H.p.]

295 (200-300′). Williamson's Quarry, in Quarry Street. A huge excavation, now disused. Chalk very hard. Resembles the preceding, but the flint courses and the bedding are better seen. Dip about 8°. Many fossils in H.p. zone; *Holaster planus*, *Micraster cor-bovis*, *M. leskei*, gibbous form *Echinocorys*, *Pentacrinus*, etc. [T.g.: H.p.: ? C.t.]

295A (170-250′). Rifle Range pit. This is practically a continuation of the previous section, but contrasts in the entire absence of flints, except at top of north end. Upper part marly and massive with few fossils. Lower part much shattered by bullets. *Discoidea dixoni* on fallen block. [R.c.: T.g.: H.p.]

296 (300′). Wilderness Farm pit. Small, chalk white and soft, scattered flints abundant with two ill-defined bands. Dip about 15° N. [U.: M.t.]

297 (320′). Manor Farm pits. Flints numerous and a thin tabular band which is much shattered. Well sculptured *Marsupites* plates common. [M.t.]

298 (320′). Down Place pit. Very small. On same horizon as preceding.

299 (360-400′). Artington pit. Nearly half-mile S. of No. 296. On south flank of Hog's Back about 50 ft. below the crest. Chalk hard, white and massive. Flints numerous, in bands and scattered nodules. In the upper part a thick tabular

No.

band with a band of hard, yellow, nodular chalk above it (in which *Micraster præcursor* of C.t. zone type is common) apparently marks the zonal junction. 20 ft. below this is a marl band. [H.p.: C.t.]

300 (300′). One-sixth mile W. of No. 299. Very old, full of trees.

301 (330′). Cherry pit. Very old, full of wild cherry trees, but with a small exposure which yielded *Glyphocyphus radiatus*. Chalk hard and marly. [? T.g.]

301A (300′) Conduit Farm pit. Called "Old Sandpit" on map. Very small; chalk very hard, dark coloured, no flints. [? R.c.]

200 yards to the south is a pit in the Lower Greensand (Folkestone sands). In this short distance there is not room for the outcrop of the whole of the Gault, Upper Greensand, and Lower Chalk, and probably part of the zone of *R. cuvieri* also. Some of the beds are evidently cut out by the Chantries strike-fault, which has not yet died away.

302 (325′). Down Lane pit. At foot of scarp. Worked in patches. S. end shows typical grey chalk, and the N. end hard white chalk with *R. cuvieri*. *A. plenus* marl not seen. A little to the S. is the artistic pottery (Gault) established by the late G. F. Watts, R.A. [H.s.: R.c.]

SHEET 31 N.W. WANBOROUGH AND PUTTENHAM.

303 (330′). At Chalkpit Farm. Very large old pit, much overgrown and badly weathered. Talus yielded *Uintacrinus*, &c. [U.]

304 (330′). One-third mile W. of preceding. Deep circular pit full of trees; no exposure.

305 (310-340′). At East Flexford. A very long, narrow and deep pit, mostly overgrown. Dirty exposure at east end. Chalk white and soft with numerous flints. Dip about 15 degrees N. [M.t.]

306 (340′). Quarter mile E. of Wanborough Church. Very old. A large and deep excavation now full of trees.

307 (310′). Close to Wanborough Church. Very small; rather rubbly soft chalk. [M.t.]

308 (350-380′). Wanborough South pit. One-third mile S. of No. 307. Chalk white, hard and tough, fossils few, flints abundant, mostly in bands. Dip about 25° N. [C.a.]

309 (450′). Puttenham Upper pit. On crest of Hog's Back. Small, mostly grassed over, but one small exposure yielded typical fossils of the zone, including a *Trochus*. [H.p.]

309A (450′). Quarter mile E. of preceding. A long, narrow trench, full of trees.

No.

310 (390′). Puttenham West pit, not visited, classed by Survey as Upper Greensand, *Cret. Mem.*, vol. i, p. 102.

311 (380-400′). Puttenham East pit. Large pit, but little worked. Massive grey chalk with Marcasite nodules. [H.s.]

312 (360-480′). Monkshatch. A very large pit in private grounds, now disused. A series of detached exposures affords a fairly continuous section. (See *Cret. Mem.*, vol. iii, p. 176.) In the upper part the yellow nodular band at base of C.t. zone seen in No. 299 is also found here (and in the next pit), but the band of tabular flint below it is much thinner. Dip about 25° N. [T.g. : H.p. : C.t.]

312A (400-480′). Mrs. Sturgess's pit. A long, narrow and deep trench just W. of the preceding, and showing similar section to its upper part. [H.p. : C.t.]

313 (450-475′). Pitfield House pit. Close to crest of Hog's Back. Small and much overgrown. [H.p.]

314 (420-450′). Inwoodbarn pit. Moderate size, chalk hard, with many flints in bands, fossils few. Dip about 50° N. [C.a.]

315 (330′). Shoelands pit. Small and much overgrown. No fossils. See *Cret. Mem.*, vol. i, p. 102.

315A (380′). Small roadside section 50 ft. above preceding. Massive grey chalk with Marcasite nodules. [H.s.]

SHEET 30 N.E. SEALE.

316 (400-440′). White Lane pit. Very large, but little used. Chalk white and hard, with many flint courses. Fossils few, probably in the barren lower third of zone. Dip 60° N. [C.a.]

317 (350-420′). Seale Lime Works, in Wood Lane. See *Cret. Mem.*, vol. ii, p. 55. Near to the preceding, but on opposite (S.) side of Hog's Back. Very large. Lower part massive grey chalk with 4 to 5 ft. of *A. plenus* marl at top, succeeded by rough blocky nodular chalk, containing *Discoidea dixoni*, *I. mytiloides*, &c. Dip 60° N. curving to 70° at the top. [H.s. : R.c. : ? T.g.]

318 (380′).

319 (360′).

320 (390′). Near Poyle Hill House. Deep, bowl-shaped pit, full of trees.

321 (360′). Victory North pit. A long, deep pit, full of trees.

322 (280-370′). The Victory pits. These two pits form

323 practically one large pit, as they are separated merely by a roadway which runs along the junction of the Middle and Lower Chalk. *A. plenus* has been found here, and the marl-band can be seen in places at the top of the lower pit.

No.

The upper is the older and larger, but the lower is the one principally worked now (see *Cret. Mem.*, vol. ii, pp. 55, 386, 388, and vol. iii, p. 176.) [H.s.: Rc.: T.g.: H.p.]

324 (340′). Tongham Lane pit. On crest of Hog's Back at corner of lane leading to Tongham. A long narrow pit running across the strike. Chalk much disturbed; dip increases from about 45° at N. end to nearly vertical at S. end. Fossils mostly broken. [C.t.: C.a.]

324A (330′). A few yards S. of No. 324. Overgrown, no exposure.

324B (270′). Near Grange Farm, Tongham. A small exposure in an old pit, several plates of *Marsupites* found. [M.t.]

325 (300′). This is the N.E. pit of a group of four shallow pits at western end of the Hog's Back. Very hard, dull, white chalk, with numerous flints, many of which are shattered. High dip. The other three pits are now overgrown. [H.p.]

326 (280′). Badshot Farm, North pit. Large, old pit, much overgrown. Chalk very white, flints numerous, fossils scarce. Dip about 40° N. [? C.t.: C.a.]

327 (270′). Badshot Farm, South pit. For full description see p. 434. [A.v.: H.s.—T.g.: ? H.p.]

SHEET 30 N.W. FARNHAM.

328 (280′). Trimmer's Hospital pit. A long trench-like pit, under fence of Farnham Park. Greyish, flintless chalk, darker when wet. [H.s.]

328A (300′). On N. flank of strike valley in Farnham Park, grassed over.

329 (300′). Hop Field pit, Farnham. Quarter mile W. of Castle. Very small. Chalk marl, very dark when wet. several typical fossils found. [A.v.]

329A (320-370′). In face of scarp, 200 yards N.W. of the preceding. Large, but old, and full of trees.

330 (310′). Claypit Gully pit. At lower end of Gully, near Crondall Lane. Small. Creamy flintless chalk with marly bands at S. end, but whiter with a few scattered flints at N. end. Dip about 45°. Fossils few. [T.g.: ? H.p.]

331 (310′) Lower Old Park Gully pit, half mile W. of No. 331, which it much resembles. [T.g.]

Two other pits near Dippenhall, marked on 6-in. map as "Old Quarry" and "Chalk Quarries" respectively, are both in Upper Greensand. The latter is described in *Cret. Surv. Mem.*, vol. i, p. 109.

Total number of sections in each zone: A.v. 4; H.s. 18; R.c. 14; T.g. 17; H.p. 20; C.t. 9; C.a. 20; M. 18.

LIST OF FOSSILS FROM THE CHALK OF SURREY.

In compiling the following list of fossils I have attempted to indicate the relative abundance of the species in the various zones, but further search may possibly modify some of the proproportions given.

No species is recorded on the evidence of bought specimens alone, every one mentioned having been found either by myself or by Messrs. Johnson and Wright in my presence. This accounts for the paucity of the list in certain groups which are more frequently found by the quarryman than by the geologist himself. It is sometimes asserted that chalk fossils are not easily found by the amateur, but, in my experience, given a moderate amount of perseverance, a fair list can usually be made without much difficulty.

The list is poor in sponges, which, although not uncommon, are generally badly preserved; but most of the species of *Porosphæra* can be found with a little patience.

Echinoderms are very abundant. I have not attempted to identify the Asteroidea, of which only isolated ossicles were found, but happily Mr. Spencer's recent work on this group will render this task more easy in the future. The Echinoidea afford some of the most reliable zonal guides for the shape variations of *Echinocorys*, and the details of ornament in *Micraster* hold good in a remarkable way. The tumid variety of *Conulus albogalerus* is rather common at the top of the C.a. zone.

Thanks to the kindness of Mr. Lang, I am able to give a long list of Cyclostomatous Polyzoa, but a quantity of the Cheilostomatous group is still awaiting examination. The Brachiopoda are rich in individuals though not in species, but *Terebratulina Rowei* is decidedly rare, while *T. striata* ranges from top to bottom.

Lamellibranchs are very widely spread and plentiful. *Ostræa* and *Inoceramus* were usually found as fragments only, and specific determination is difficult. Gasteropods and Cephalopods are rather rare, but further search in the lower zones would probably yield additional species of Ammonites.

Sharks' teeth do not often fall to the share of the searcher, although so frequently found by the quarryman, whose eye is caught by their conspicuous form and colour, and the list of this group is meagre. Fish scales are often met with, but they occur mostly as the lining of the worm tubes of *Terebella lewesiensis*.

C = common ; × = moderately common ; R = rare.
Zonal abbreviations as given on p. 441.

	A. v.	*H. s.*	*R. c.*	*T. g.*	*H. p.*	*C. t.*	*C. a.*	*M. t.*
Placopsilina cenomana, *d'Orb.*	...	...	...	...	×	...	...	×
Cliona cretacea, *Port.*	...	...	...	...	...	...	×	...
Doryderma ramosum, *Mant.*	...	...	...	...	...	...	×	×
Pharetospongia strahani, *Sollas*	...	...	...	...	...	...	...	×
Plinthosella squamosa, *Zitt.*	...	...	...	×	×	...	C.	C.
Porosphœra arrecta, *Hinde*	...	...	...	...	...	...	...	R.
„ globularis, *Phil.*	...	...	R.	...	×	×	C.	C.
„ nuciformis, *von Hag.*	...	...	...	...	...	...	×	C.
„ patelliformis, *Hinde*	...	...	...	...	×	×	×	×
„ pileolus, *Lam.*	...	...	...	...	...	...	×	C.
Siphonia Königi, *Mant.*	...	...	...	...	...	...	...	×
Ventriculites impressus, *T. Smith*	...	...	...	×	×	×	...	×
„ radiatus, *Mant.*	...	...	...	×	×	...	...	...
Hydrozoa	...	...	...	...	×	×	×	×
Parasmilia centralis, *Mant.*	...	...	...	R.	R.	×	×	×
Spinopora dixoni, *Londs.*	...	...	...	...	..	R.	...	R.
Synhelia sharpeana, *E. & H.*	...	...	...	...	...	...	R.	...
Asteroidea	...	...	R.	...	×	×	C.	C.
Bourgueticrinus, *sp.*	...	...	...	...	C.	×	C.	...
„ nipple-head	...	...	...	...	...	...	...	×
Cardiaster pygmæus, *Forbes*	...	...	R.	...	...	...	...	...
Cidaris Bowerbanki, *Forbes*	...	R.	...	...	...	...	...	...
„ clavigera, *Kœnig*	...	...	...	...	×	×	C.	×
„ dissimilis, *Forbes*	?	...	...	...	...	...	...	...
„ hirudo, *Sorig.*	...	...	...	...	..	...	C.	C.
„ perornata, *Forbes*	...	...	...	...	...	...	×	×
„ sceptrifera, *Mant.*	...	...	...	...	×	×	C.	×
„ serrifera, *Forbes*	...	...	...	×	×	×	...	...
„ subvesiculosa, *d'Orb.*	...	...	...	...	...	...	...	R.
Conulus albo-galerus, *Leske.*	...	...	...	...	...	...	C.	×
„ „ tumid form	...	...	...	...	...	...	C.	C.
„ sub-rotundus, *Mant.*	...	...	×	×	...	...	...	...
Cyphosoma corallare, *Klein*	...	...	...	...	...	...	R.	...
„ königi, *Mant.*	...	...	...	...	...	...	×	R.
„ radiatum, *Sorig.*	...	...	...	×	C	...	...	...
Discoidea cylindrica, *Lam.*	...	×	...	...	...	...	...	...
„ dixoni, *Forbes*	...	...	×	...	...	...	...	...
Echinoconus (*see* Conulus)	...	...	...	...	...	...	...	...
Echinocorys scutatus, *Leske* (gibbous)	...	...	...	...	C.	C.	...	...
„ „ „ (large dome)	...	...	...	...	...	...	C.	...
„ „ „ (sub-pyramidal)	...	...	...	...	...	...	...	C.
„ „ „ (tall dome)	...	...	...	...	...	...	...	C.
Epiaster gibbus, *Lam.*	...	...	...	...	...	...	R.	...
Glyphocyphus radiatus, *Hœn.*	...	...	...	?	..	...	...	...
Hemiaster minimus, *Ag.*	...	...	R.	...	...	...	...	...
Holaster placenta, *Ag.*	...	...	...	...	C.	C.	R.	...
„ planus, *Mant.*	...	...	R.	R.	×	...	...	...
„ subglobosus, *Leske*	...	×	...	...	...	...	...	...
„ trecensis, *Leym.*	?	R.	...	...	...	...	...	...
Infulaster concentricus, *Rose*	...	...	...	...	...	...	R.	...
Marsupites testudinarius, *Schloth*	...	...	...	...	...	...	...	C.
Micraster cor-anguinum, *Klein*	...	...	...	...	...	...	C.	×
„ var. *rostratus*	...	...	...	...	...	...	...	R.

	A. v.	*H. s.*	*R. c.*	*T. g.*	*H. p.*	*C. t.*	*C. a.*	*M. t.*
Micraster var. *latior*	...	...	...	...	...	...	R.	R.
„ cor-bovis, *Forbes*	...	...	...	×	×	...	...	...
„ Leskei, *Desm.*	...	...	...	...	C.	...	...	...
„ præcursor *Rowe* M.c.a-. type	...	...	...	...	...	...	×	...
„ „ „ M.c.-t. type	...	...	...	...	...	C.	...	...
„ „ „ var. cor-testudinarium, *Goldf.*	...	...	...	...	...	×	...	...
„ „ „ H.p. type	...	...	...	...	C.	...	...	...
Metopaster	...	...	...	...	×	...	...	×
Pentacrinus	...	...	...	...	×	...	...	...
Pseudodiadema, *sp.*	...	R.	...	...	...	...	...	...
Salenia geometrica, *Ag.*	...	...	...	...	...	...	...	R.
Uintacrinus, *Schlüt.*	...	...	...	...	...	...	...	C.
Serpula ampullacea, *Sow.*	...	...	...	...	...	×	×	...
„ fluctuata, *S. Woodw.*	...	...	...	...	×	×	×	×
„ gordialis, *Sow.*	...	...	...	...	...	×	...	...
„ ilium, *Sow.*	...	...	...	...	×	×	×	...
„ macropus, *Sow.*	...	...	...	...	...	×	×	...
„ plana, *S. Woodw.*	...	...	...	...	×	×	×	×
„ plexus, *Sow.*	...	...	...	...	...	...	×	...
„ turbinella, *Sow.*	...	...	...	...	...	×	×	×
Terebella lewesiensis, *Davies*	...	...	...	...	...	...	×	×
Polyzoa	...	...	...	...	×	×	×	×
Actinopora complanata, *Ræm.*	...	...	...	...	...	×	...	...
„ disticha, *von Hag.*	...	...	...	...	...	...	...	×
Alecto ramea (see Stomatopora granulata)	...	...	...	...	...	...	...	...
Berenicea gracilis, *Edw.*	...	...	...	...	...	×	...	...
„ papillosa, *Reuss.*	...	...	...	...	...	×	...	...
„ phlyctænosa, *Reuss.*	...	...	...	...	...	×	...	...
„ regularis, *d'Orb.*	...	...	...	...	...	×	...	×
„ „ var. gamblei	...	...	...	...	×	...	...	...
„ *sp.*	...	...	...	...	×	×	×	...
Clausa globulosa, *d'Orb.*	...	...	...	...	...	×	...	...
Cribrillina	...	...	...	...	...	...	×	...
Cryptoglena gamblei, *Greg.*	...	...	...	...	...	×	...	...
Desmeopora pinnigera, *Greg.*	...	...	...	...	×	...	...	...
Eschara, *sp.*	...	...	×	...	×	×	×	×
Homolostega, *sp.*	...	...	...	...	×	×	...	...
Homœosolen, *sp.*	...	...	...	...	...	×	...	×
Idmonea alipes, *Greg.*	...	...	...	...	×	×	...	×
„ cristata, *Meun.* and *Perg.*	...	...	...	...	...	×	...	...
Meliceritites, *sp.*	...	...	...	...	...	×	...	×
Membranipora, *sp.*	...	...	...	...	×	×	×	×
Proboscina anomala, *Reuss.*	...	...	...	...	...	...	...	×
„ cornucopiæ, *d'Orb.*	...	...	...	...	...	×	...	×
„ crassa, *Röm.*, var. alectodes	...	...	...	...	...	×	...	...
„ crassa, *Röm.* var. francorum	...	...	...	...	...	...	×	...
„ dilatata, *d'Orb.*	...	...	...	...	...	...	...	×
„ elevata, *d'Orb.*	...	...	...	...	×	...	...	×
„ fasciculata, *Reuss.*	...	...	...	...	...	×	×	...
„ radiolitorum, *d'Orb.*	...	...	...	...	×	...	×	×
„ ramosa, *Edw.*	...	...	...	...	×	×	×	...
Reptomultisparsa rowei, *Greg.*	...	...	...	...	...	×	...	...
Reticrisina obliqua, *d'Orb.*	...	...	...	...	×	...	...	...
Stomatopora gracilis, *Edw.*	...	...	...	...	...	×	×	×

	A. v.	*H. s.*	*R. c.*	*T. g.*	*H. p.*	*C. t.*	*C. a.*	*M. t.*
Stomatopora granulata, *Edw.*	...	...	...	...	...	×	×	×
„ *sp.*	...	...	...	...	×	×	×	×
„ spicea, *Greg.*	...	...	...	...	...	×	×	...
Crania egnabergensis, *Retz.*	...	...	...	...	×	×	...	...
Kingena lima, *Defr.*	×	×	...	...	...	...	×	×
Rhynchonella cuvieri, *d'Orb.*	...	...	C.	×	×	...	...	...
„ limbata, *Schloth.*	...	...	...	...	×	×	...	...
„ mantelliana, *Sow.*	×	×	...	...	...	...	...	...
„ martini, *Mant.*	×	×	...	...	...	...	...	...
„ plicatilis, *Sow.*	...	...	...	...	C.	R.	C.	C.
„ „ var. octoplicata	...	...	...	...	×	...	...	...
„ „ var. woodwardi	...	...	...	...	R.	...	...	...
„ reedensis, *Eth.*	...	...	...	...	C.	R.	C.	C.
Terebratula carnea, *Sow.*	...	...	R.	R.	C.	C.	C.	...
„ ovata, *Sow.*	×	...	...	...	...	...	...	...
„ semiglobosa, *Sow.*	×	C.	×	×	C.	C.	×	...
„ squamosa, *Mant.*	...	×	...	...	...	...	...	...
Terebratulina gracilis, *Schloth.*	...	...	...	C.	C.	...	...	...
„ rowei, *Kitchin*	...	...	...	...	...	...	...	R.
„ striata, *Wahl.*	×	×	×	×	×	×	×	×
Thecidium wetherelli, *Morris*	...	...	×	...	×	...	×	×
Pollicipes, *sp.*	...	...	...	...	...	...	...	R.
Scalpellum maximum, *Sow.*	...	...	...	...	...	...	R.	R.
Caprotina, *sp.*	...	...	...	...	...	...	R.	...
Inoceramus latus, *Goldfuss*	×	×	...	...	...	...	...	...
„ mytiloides, *Mant.*	C.	×	...	...	...	...	...	...
„ *sp.*	×	...	...	×	C.	C.	C.	C.
Janira, see Pecten (Neithea)	...	...	...	...	...	...	...	...
Lima globosa, *Sow.*	R.	...	...	...	...	...	...	...
„ hoperi, *Sow.*	...	...	...	...	R.	R.	×	...
Ostræa hippopodium, *Nilss.*	...	...	...	...	×	×	...	...
„ lateralis, *Sow.*	...	...	...	...	...	...	×	×
„ semiplana, *Mant.*	...	...	...	...	...	...	×	...
„ *sp.*	×	×	×	×	×	×	×	×
„ vesicularis, *Lam.*	...	×	...	...	...	...	×	×
„ wegmanniana, *d'Orb.*	...	...	...	...	...	...	...	×
Pecten cretosus, *Defr.*	...	...	...	...	R.	R.	C.	×
„ (Neithea) quinquecostatus, *Sow.*	...	...	...	×	×	C.	C.	C.
„ orbicularis, *Sow*	×	×	...	...	...	...	...	...
Pholadomya decussata, *Phil.*	R.	...	...	...	...	...	...	...
Plicatula barroisi, *Peron*	R.	...	R.	...	C.	...	...	...
„ inflata, *Sow.*	×	×	...	...	...	...	...	...
„ sigillina, *S. P. Wdw.*	...	...	...	...	...	C.	C.	C.
Septifer lineatus, *Sow.*	...	...	...	...	...	...	...	R.
Spondylus dutempleanus, *d'Orb.*	...	...	...	R.	×	×	C.	...
„ latus, *Sow.*	...	...	...	R.	R.	C.	C.	C.
„ spinosus, *Sow.*	...	...	...	C.	C.	C.	C.	C.
Pleurotomaria, *sp.*	R.	...	...	...	...	...	...	...
Trochus, *sp.*	...	...	...	...	R.	...	...	...
Actinocamax granulatus, *Blainv.*	...	...	...	...	...	...	...	×
„ plenus, *Blainv.*	...	×	...	...	...	...	...	...
„ verus, *Miller*	...	...	...	...	...	...	×	×
Ammonites (Acanthoceras) navicularis, *Mant.*	R.	R.	...	...	...	...	...	...
Ammonites (Acanthoceras) rotomagensis, *Defr.*	R.	×	...	...	...	...	...	...

	A. v.	*H. s.*	*R. c.*	*T. g.*	*H. p.*	*C. t.*	*C. a.*	*M. t.*
Ammonites (Pachydiscus) peramplus, *Mant.*	...	...	R.	...	...	...	...	...
Ammonites (Schloenbachia) varians, *Sow.*	×	...	...	...	...	...	...	...
Hamites armatus, *Mant.*	R.	...	...	...	...	...	...	...
Crioceras ellipticum, *Mant.*	...	...	...	...	R.	...	...	...
Nautilus deslongchampsianus, *d'Orb.*	R.	...	...	...	...	...	...	...
Scaphites æqualis, *Sow.*	R.	...	...	...	...	...	...	...
Turrilites scheuchzerianus, *Bosc.*	...	R.	...	...	...	...	...	...
Corax falcatus, *Ag.*	...	...	...	R.	R.	...	...	...
Enchodus, *sp.*	...	...	...	R.	...	...	...	...
Lamna appendiculata, *Ag.*	...	...	R.	R.	...	...	...	...
Oxyrhina mantelli, *Ag.*	...	...	...	...	R.	...	...	...
Ptychodus decurrens, *Ag.*	...	...	R.	R.	...	...	...	...
„ mammillaris, *Ag.*	...	...	R.	...	...	...	...	...
„ polygyrus, *Ar.*	...	...	...	...	...	...	R.	...

ORDINARY MEETING.

FRIDAY, MARCH 6TH, 1908.

PROF. W. W. WATTS, F.R.S., President, in the Chair.

The following were elected members of the Association: Christopher James Alexander, Mrs. H. Hendriks, Norman McCracken, Frederick Richard Lanfear Miller, Herbert David Schloss, Ivan J. Thatcher, A.M.I.C.E.

The following lecture was then delivered: "The After-history of the West Indian Eruptions of 1902," by Tempest Anderson, M.D., D.Sc., F.G.S. The lecture was copiously illustrated with lantern slides, showing the enormous amount of denudation that had taken place in a very short period.

On this occasion the Association was joined by the University College Old Students' Association, of which the lecturer was President.

Prof. Watts proposed a hearty vote of thanks to Dr. Tempest Anderson. This was seconded by the Provost of University College and carried unanimously. In the course of his remarks the Provost said he would take the opportunity of thanking the Geologists' Association for their valuable gift of the library which had recently been presented to the College. He assured those present of the gratification of the College Authorities at the cordial relations so long subsisting between the two bodies, and said that if at any time the members of the Association felt that some change in the details of arrangements was desirable he hoped they would not suffer in silence.

The President offered the thanks of the Association to the Old Students' Association for their hospitality and for the entertainment which was to follow the lecture. He also took the opportunity of the presence of the Provost of University College to thank the University Authorities for the uniform courtesy and consideration which the Association had always met with at their hands.

The members then adjourned to the refectory, where they were entertained by the University College Old Students' Association, who also afterwards provided an excellent musical programme in the Mocatta Library.

ORDINARY MEETING.

FRIDAY, APRIL 3RD, 1908.

PROF. W. W. WATTS, F.R.S., President, in the Chair.

The following were elected members of the Association: J. A. Bullbrook, Miss K. N. Fitzsimmons, Miss Edith Goodyear, Frederick Henry Hatch, Ph.D., M.I.C.E., F.G.S.; Miss F. J. Relf, B.Sc.; John Vick Thomas, A.M.I.M.E.

The following lecture was delivered: "Coral Islands in the Light of Modern Investigations," by C. Gilbert Cullis, D.Sc., F.G.S. The lecture was illustrated by lantern views. A vote of thanks was moved by the President and seconded by Dr. Teall, who showed slides of Clipperton atoll and gave an explanation of them.

In illustration of the Easter excursion two series of fossils from the Paris Basin were shown by Messrs. J. Francis and T. W. Reader.

ORDINARY MEETING.

FRIDAY, MAY 1ST, 1908.

Prof. W. W. WATTS, F.R.S., President, in the Chair.

The following were elected members of the Association: James Byrne, Arthur H. Gehrke, F.R.G.S., Edward Alfred Martin, F.G.S., F. Edward Norris.

The following paper was then read: "Structural Analogies between Alloys and Igneous Rocks," by William George Fearnsides, M.A., F.G.S. The lecture was illustrated with lantern slides. A short discussion ensued, in which Messrs. Whitaker, Elsden, Tinker, and the President took part.

EXCURSION TO DARTFORD AND STONE.

SATURDAY, FEBRUARY 29TH, 1908.

Directors: E. C. YOUENS and S. PRIEST, F.G.S.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTORS)

A PARTY of 38 assembled at Dartford Station at 2.45 p.m., where they were met by Mr. Youens and proceeded by tram to Stone, whence a short walk brought them to the Stone Court Chalk Pit.

Mr. Youens said:

"One of the most perplexing problems encountered by students in archæology is that of the origin and purpose of those ancient caverns in the chalk commonly called dene-holes. These relics abound in this neighbourhood, and the position of ninety-seven is indicated on the 6 in. Ordnance map Kent Sheet ix. It will be noticed how thickly they are clustered in Stankey Wood, near Dartford, but a still more numerous assemblage exists in Cavey Spring Wood (which is partly outside the range of the map), making the total number for this district, within a range of 6 by 4 miles, about 200. Very few of them have been explored, owing to the difficulty of drawing the *débris* up the generally deep and narrow shaft, and when this has been done the relics discovered have usually been the bones of unfortunate animals that have fallen down the shaft, and must have suffered a lingering death from thirst and starvation.

"In the dene-holes explored by the Essex Field Club at Hangman's Wood, Grays Thurrock, were found the bones of human beings, the horse, ox, sheep, pig, goat, dog, fox, cat, badger, pole-cat, stoat, weasel, rabbit, hare, rat, and other species.

"Mr. F. C. J. Spurrell, in describing two of these pits (revealed in a similar manner to that we are now inspecting) in the chalk pit at Crayford, stated—'They were filled in with rubbish. One of them (the eastern) measured from the surface to the chalk 18 ft., thence to the floor 17 ft. 6 in. The floor was of flint, from 6 in. to 9 in. thick, which had been taken up, and piled in a heap at the side of the chamber. No tool marks of metal were found on the walls. From the floor rose an obtuse cone of sandy clay, washed in very slowly by the rain. Flakes, scrapers, &c., of the Neolithic Stone Age, were found in this clay; then a layer of Roman and Romano-British pottery; then bones and rubbish to the top. If we remember the time which has passed since the deposit of the Roman remains, we can estimate that which passed previously to the time when the soil began to wash into it after its abandonment.'

"The general characteristic of dene-holes is a perfectly straight shaft, passing through the soil until the chalk is reached, which sometimes occurs at a depth of 12 ft. or less (as is the case with the example we are now inspecting); in other places the chalk is at a much lower level, as at Abbey Wood, where the shafts are 50 ft., and at Eltham 120 ft. They are generally (when perfect) about 2 ft. or 3 ft. in diameter, and many have foot-holds to aid the users in ascending and descending. In others may be seen the scoring in the sides caused by a rope, used probably for the same purpose, or for extracting the chalk. Sometimes the shaft was protected at the upper part by 'steining' with flints to prevent the sand and gravel falling. I am able to show you an enlarged photograph of an example of this, discovered adjacent to Heath-lane, near the east side of Dartford-Heath, in 1896. This shaft was quite choked up, and had not been explored.

"The shaft usually gives access to more or less symmetrically excavated chambers in the chalk. In Kent, examples occur with one, two, three, and (as is the case here) six chambers. Two good examples of the single trefoil plan dene-hole existed in Shepherd's-lane, Dartford. In one of them the rough sides of the three caves were covered all over with the marks of a pointed implement, like a pick. The depth from the surface to the floor of the caves was 38 ft. Both are now filled up.

"Most of the dene-holes in Grays Thurrock had six chambers, arranged in double trefoil plan. It is important to note that, although the shafts are so thickly clustered together, both at Grays and Cavey Spring and Stankey Woods, there is no communication between the caves under-ground, and this fact, I think, furnishes us with a strong argument against the theory that they were dug merely for the sake of the chalk. And why did they labour at so many shafts, when one or two would have sufficed? Again, why dig down 50 ft. or 100 ft. for chalk, when it could be got almost on the surface a short distance away?

"With some diffidence, I venture to express the opinion that these workings are pre-Roman, since several instances are recorded of dene-holes having been utilized by that people as rubbish pits. Again, this field was used as a cemetery in Roman times, and skeletons, with various fictile vessels, have been found there, close by the spot where the shaft of the dene-hole came to the surface. I think it must have become filled up before their time, or they would not have selected that as a burial-place. Owing to the kindness of J. J. Hewitt, Esq., J.P., the Roman vessels found are now preserved in the Dartford Museum.

"The work of excavating the fallen soil and *débris* in the Stone Court dene-hole was commenced on Tuesday, 25th

February, when the north chamber was cleared, and a photograph taken of the section exposed on the left of the shaft looking south. The chalk floor of this chamber was level and smooth. It is 13 ft. 6 in. long by 8 ft. wide, and 17 ft. 9 in. from floor to apex of roof. In it were found several bones and snail shells.

"Four other chambers were cleared on the following days so that only one remained filled with *débris* at the time of the Association's visit on the 29th February. A small piece of tile, probably Roman, was found about 1 ft. above the floor, and a number of bones on the floor shelf. The greater number of these bones are the remains of several dogs; but there are a few bones of ox, sheep, horse, and hare.

"In conclusion, I eagerly seize this opportunity of expressing our great indebtedness to the Stone Court Quarry Co. and J. J. Hewitt, Esq., J.P., C.C., for their kindness in allowing us such unique facilities for inspecting this interesting relic of bygone ages. I should also like to acknowledge the personal kindness of Mr. H. Coulter (the foreman), and also the intelligent interest taken in the work by the men—John Dooney, Albert Hibben, and W. Burgess, who gave every assistance in preserving the relics." *

After an hour spent in the dene-hole, discussing the probable age and use of these excavations, the party had a pleasant walk of half a mile or so to the village of Stone, where, in the schoolroom, Mr. S. Priest had set out for inspection a large series of fossils collected by himself in different parts of England. Among the more particularly interesting of these were a series of ironstone nodules from Staffordshire containing not only well preserved fern fronds, but also a number of arachnids and crustacea. There were likewise some good trilobites and other fossils from the Wenlock limestone of Dudley, good examples of which are so rarely collected nowadays. Oolitic and cretaceous fossils were also included as well as some good examples of flint implements recently obtained from Swanscombe.

After a visit to the remarkable Church at Stone, the interior of which reminds one of Westminster Abbey, the party returned by special electric car to the Dartford Technical Institute, where a Museum is just being formed. Mr. E. C. Youens, who is the moving spirit of the enterprise, explained what was being done, and showed some of the specimens already brought together. There are some interesting Roman remains of local interest; a large number of pebbles from the Dartford gravels, collected by Mr. Ralph Youens, includes an unusually varied series of quartzites, radiolarian and

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* NOTE.—From a dene-hole in Darenth Woods, explored by Mr. Priest since the Excursion, Mr. E. T. Newton has identified many bones of several dogs, also fox, badger, hare, rabbit, sheep, rook (or crow), and water-wagtail. There is likewise one human finger bone.

Rhaxella cherts, also chert of Carboniferous age and some rolled specimens of *Gryphæa* (Jurassic), and many other rocks; some fine Palæolithic implements, together with mammoth and other mammalian teeth and bones, had been found only a few days before the visit of the Association; and an ammonite preserved in flint, which had been found in West Hill Chalk Pit, Dartford.

A hearty tea was enjoyed at the "North Pole" restaurant, after which votes of thanks were passed to the directors, Mr. E. C. Youens and Mr. S. Priest. There being time to spare, the discussion on the "Dene-holes" was resumed.

Mr. W. Johnson, F.G.S., said, whilst inclining to the belief that the dene-holes were dug primarily to obtain chalk, he felt that there were several strong points in favour of the granary theory, and that underground storage may have been a secondary purpose. Frequently, the dene-holes were grouped in woods, and it must be remembered that Cæsar described a British fort as a wood surrounded by a ditch. Some of these dene-hole copses may be representatives of primeval woodlands. Moreover, apart from the statements of Diodorus Siculus with reference to subterranean storage of corn in Britain, we had the fact that such a method of preserving corn had been common at various times in many widely-separated countries. In addition, analogous structures, though much smaller, had been discovered in the Isle of Portland and elsewhere.

Nevertheless, other considerations must be faced. There is the direct assertion of Pliny that the Britons of his day marled their land with chalk. Pliny's description of the "wells" from which chalk was dug corresponded more closely with the known features of dene-holes than the granary advocates will admit. That chalk was an article of export, apparently in the "Romano-British" period, was proved by the discovery, in 1646, of votive altars to Nehallenia, set up on the coast of Zealand, in the Netherlands, by one Silvanus, a British chalk merchant.

Indeed the whole history of the use of chalk as a dressing for fields, besides being most interesting, tended strongly to prove that the dene-holes were a special kind of chalk pit, though they might have been subsequently put to other uses.

Mr. A. L. Leach considered dene-holes to be chalk pits pure and simple. The arrangement of chambers round the base of the shaft yielded the maximum quantity of chalk with the minimum amount of risk and labour. The thickness of the overlying Tertiary strata had been brought forward as an argument against the "chalk pit" theory. He however thought it told against the "granary" theory to a greater extent than for it. If underground chambers were needed for storage of grain, galleries or chambers sunk directly into the chalk where it was not overlain by Tertiary strata would have afforded as much concealment and would have been much more easily excavated than these dene-holes, which are frequently sunk through 40 ft. to 60 ft. of sands and loams. The oft-quoted reference of Pliny undoubtedly supported the theory that dene-holes were simply chalk pits (for agricultural purposes), and the "granaries" or "grain pits" mentioned by Diodorus Siculus were the *shallow* pits which have been found not only in chalk but in Oolitic limestones and other rocks. Dene-holes always appeared to be sunk through those soils which would be greatly benefited by the application of chalk as a manure.

Mr. Youens said he was not particularly concerned with the consideration of what was done with the chalk excavated from these pits. What he wanted to get at was the period at which they were dug. He admitted there was little actual evidence to go upon, but he felt convinced they were decidedly pre-Roman.

Mr. E. T. Newton, F.R.S., F.G.S., said that the evidence to be derived from the mammalian bones which had been found was not in favour of the dene-holes being of any great age. It was remarkable that only remains of quite modern, present-day animals had been found, including dog, horse, ox, sheep, pig, cat, rabbit, rat, etc.

The discussion continued until the party took train for London, thus ending a much appreciated excursion, notwithstanding the early time of the year at which it was taken.

VISIT TO THE CANADIAN MINERAL GALLERY, IMPERIAL INSTITUTE, SOUTH KENSINGTON.

SATURDAY, MARCH 7TH, 1908.

Director: J. W. EVANS, D.Sc., LL.B., F.G.S.

(*Report by* THE DIRECTOR.)

ON entering the Gallery Dr. Evans directed the attention of the members of the Association (of whom forty-five had assembled) to the Canadian fuels. Coal of Carboniferous age, contemporaneous with that of our coalfields, is found in Nova Scotia and New Brunswick, though the output in this latter province is comparatively small. Coal is not found in Quebec and Ontario, but farther west it is met with of Cretaceous age. Where it lies undisturbed in the central plains it has the characters of lignite, but in the neighbourhood of the Rocky Mountains the strata are affected by earth-movements and the dislocations have allowed the volatile constituents to escape, so that it passes into bituminous coal or even anthracite. Among other localities may be mentioned Canmore, near Banff, in Alberta, the Crow's Nest Pass in the Rockies of British Columbia, and Nanaimo in Vancouver Island. Tertiary coal occurs in British Columbia and the Yukon, and peat is found in many localities. Mineral oils have been extensively worked in Ontario, and to a less extent in New Brunswick, where bituminous deposits are also met with.

There is a large exhibit of graphite, which occurs in Quebec, Ontario, New Brunswick, and Nova Scotia. As in Ceylon, Bavaria, and other localities it appears to be a deposit formed in crystalline rocks by pneumatolytic action. In Charlotte County, New Brunswick, however, graphite occurs which appears to have resulted from the metamorphism of coal-seams as in Styria.

In the same large wall case are some fine specimens of mica, another product of the ancient crystalline rocks. Muscovite (potash mica) is found in "books" (crystals) of broad plates in coarse pegmatoid veins in the gneiss of the Province of Quebec, but is not systematically mined on account of its irregular occurrence. Of more importance commercially is silver-amber mica or phlogopite (magnesia mica), which is found in pyroxene dykes with calcite and apatite in Ottawa County, Quebec, and to the south-west of Ottawa in the province of Ontario. Though silvery in appearance it is nearly opaque, the result of innumerable small interlamellar bubbles. It is mainly used for electrical purposes, either in its natural state or in the form of micanite, which consists of thin films cemented together.

Another wall case is devoted to Canadian "asbestos," the chrysolite of mineralogists, and the amiantos or Karystian stone of the Greeks. Here as elsewhere it occurs in serpentine rock, the ancient Karystian marble. It was contrasted with the "blue asbestos" or krokydolite of Griqualand West in Cape Colony, which was also shown. The asbestos of mineralogists is worked to some extent in Hastings County, Ontario, under the name of actinolite, while in the United States there is another asbestos which is a variety of anthophyllite. There are, therefore, four distinct fibrous minerals employed in the arts, but chrysolite is by far the most valuable.

The nickel ore of Sudbury, near Lake Superior, occupies another wall case. It is a nickeliferous pyrrhotite, closely associated with a norite (hypersthene gabbro) which forms the lower portion of a thick sheet of igneous rock (now lying in a synclinal basin) of which the upper part is distinctly acidic. The association of nickel with ferrous sulphide and orthorhombic pyroxene is common both in the earth's crust and in meteorites.

Some fine specimens of the cobalt nickel silver ores that occur in dykes in Huronian rocks near Lake Temiskaming were also seen.

The whole of another wall case is occupied by specimens of felspar-corundum rock and grindstones, etc., manufactured from the latter mineral. As in other parts of the world the rock is a marginal facies of nepheline syenite.

Limit of space forbids more than the simple enumeration of other Canadian mineral products: gold from Nova Scotia, Ontario, the Klondyke, and British Columbia; lead and silver from Ontario and British Columbia; copper from British Columbia and Nova Scotia; iron and manganese from Nova Scotia, Quebec and other localities; gypsum; zinc blende; apatite; and potash felspar, the last-mentioned occurring in large crystals and being employed in the manufacture of porcelain.

For further details reference may be made to the Bulletin of the Imperial Institute, vol. i, pp. 98, 183; vol. ii, pp. 115, 116, 291; vol. iii, p. 281; vol. iv, pp. 55, 261, 371; vol. v, pp. 80, 282, 293, and various publications on the Mineral Resources of Canada by the Geological Survey of the Dominion, and the Mines Branch of the Department of the Interior, Ottawa.

The proceedings terminated with a hearty vote of thanks to the Director proposed by the President. Dr. Evans, in replying, said there were other colonial exhibits of geological interest, which he invited the Association to visit on some future occasion.

VISIT TO THE WESTERN GALLERY OF THE VICTORIA AND ALBERT MUSEUM, AND GEOLOGICAL DIVISION OF THE ROYAL COLLEGE OF SCIENCE, SOUTH KENSINGTON.

SATURDAY, MARCH 14TH, 1908.

Directors: The PRESIDENT, C. G. CULLIS, D.Sc., F.G.S., and R. F. GWINNELL, F.G.S.

(*Report by* R. F. GWINNELL.)

A LARGE party, numbering about seventy, assembled at 2.30 at the entrance to the Western Gallery, and were met by the President. Proceeding through the gallery, which is devoted to scientific apparatus, the more important exhibits were examined, Prof. Watts giving short explanations of each.

Among those of chief interest to geologists may be mentioned the models illustrating Prof. Duparc's views as to the tectonic structure of the Alps, and Sopwith's models showing the relation of outcrop of strata to underground structure. Among the contoured relief models special attention was directed to Prof. Heim's wonderfully realistic representations of glaciated mountain scenery, to the large model of the Isle of Purbeck prepared by the *Geological Survey*, and to French exhibits illustrating the method of construction of these models. Jordan's relief map of the British Isles and surrounding seas shows in a striking manner the continental origin of our country.

A fine collection of maps illustrating the work of the official geological surveys of most foreign countries had been arranged by Prof. Judd. Near them were seen such historic maps and documents as William Smith's Geological Map of the Environs of Bath (1799), and his Table of Stratified Deposits, the earliest expression of the regular order of superposition of strata. His great map of England and Wales, published in 1815, is so hung as to be readily compared with the modern Index map of the *Geological Survey*, and one cannot but be struck by the marvellous accuracy and detail of the pioneer work.

Leaving the public gallery, the party entered the private teaching museum of the college, where Prof. Watts briefly explained its general plan, and pointed out that its arrangement was entirely due to Prof. Judd, he himself having altered it in no respect.

A brilliant demonstration was next given in the lecture theatre by Dr. Cullis on the use of the projecting lantern-microscope in the teaching of micro-petrology. The optical properties employed in the identification of minerals in thin sections were illustrated by a fine series of sections such as are used with the ordinary microscope. Meanwhile those who were unable to attend this demonstration owing to lack of accommodation, were examining, under Mr. Gwinnell's charge, the apparatus employed in slicing and grinding thin sections of rocks for microscopic examination, and also other allied machines.

After both groups had attended each demonstration tea was provided by the President. The visit terminated with a very hearty vote of thanks to Prof. Watts and the other Directors; it was proposed by Messrs. George Potter and Upfield Green, and responded to by Prof. Watts and Dr. Cullis.

VISIT TO THE BOROUGH OF STEPNEY MUSEUM, WHITECHAPEL, AND THE NATURE STUDY MUSEUM, CABLE STREET, E.

SATURDAY, MARCH 21ST, 1908.

(*Report by* T. W. READER, F.G.S.)

A PARTY of twenty-three assembled at the Stepney Museum at 2 p.m. In the unavoidable absence of the Curator, Miss Hall, the party were conducted by the Museum assistant, Mr. P. Horn, who described the Zoological and Antiquarian Section, Mr. H. Whitehead, the late assistant, dealing with the Geological and Mineralogical Section. It was explained that the museum owes its origin to the munificent gift by the Rev. Mr. Greatorex, the Vicar of Whitechapel, of his collection of Antiquities, as well as of Geological and Natural History specimens, to the Stepney Borough Council, who enthusiastically accepted the gift, and provided the necessary room in the library buildings at 77, High Street, Whitechapel. The arrangement of the museum is on the plan of evolution, commencing in the wall-cases with the Invertebrates, many fine specimens of Coral, Echinoderms, Mollusca, and Crustacea being pointed out. Then follows an interesting educational series of specimens of Fish, Reptiles, Birds, and Mammals, concluding with Man, his weapons and tools. In the table-cases are arranged special collections, British Mollusca, &c., Ores and Minerals and an interesting series of Fossils being the united collections presented by the Geologists' Association, the Rev. Mr. Greatorex, Dr. Gregory and the Toynbee Scientific Society. A fine series of antiquarian remains relating to Norton Folgate, presented by the Trustees of the Liberty, were next examined with much interest.

In cabinets under the table-cases are stored a large series of specimens which are available to students. For the furtherance of nature study special exhibits of flowers and botanical specimens are arranged.

At 3.30 p.m. the party left the museum, and made their way to Cable Street, St. George's, where, owing to the exertions of Miss Hall, a suitable building has been transformed into a Nature Study Museum. An arrangement is made whereby parties of children can be brought and lessons given on the exhibits, which are mostly examples of the lower forms of animal-life.

Being rather early in the season there were not many flowers in the garden round the museum, but it was remarked that they were able to raise some plants on the alluvial sandy soil which cannot exist at other parts further from the river.

The party then proceeded to Toynbee Hall, where they were received by the warden, Mr. Harvey, who had prepared in the "drawing-room" a tea that was most welcome after the afternoon spent in the busy district of the docks.

The Warden then conducted the party over the Settlement. After inspecting the dining hall, art school, library and other rooms, a hearty vote of thanks was proposed by Mr. Newton and accorded by the members to Mr. Harvey for giving up his afternoon to them.

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY, JERMYN STREET.

SATURDAY, MARCH 28TH, 1908.

Director: J ALLEN HOWE, B.Sc., F.G.S., assisted by DR. J. J. H. TEALL, F.R.S., etc., W. A. E. USSHER, F.G.S., H. A. ALLEN, F.G.S., T. C. CANTRILL, B.Sc., F.G.S., E. E. L. DIXON, B.Sc., F.G.S., D. A. MACALISTER, A.R.S.M., F.G.S., and T. C. HALL.

THE party, numbering about 50, assembled in the lower Hall at 2.30; here Mr. Howe explained the general arrangement of the exhibits in the new extension of the Museum, and said that the most recent development in the Museum had been the introduction of temporary exhibits to illustrate new Memoirs, by means of specimens, maps, and photographs, which were arranged with the co-operation of the field staff. Arrangements had been made with the field officers that they might be present to demonstrate to the Association the cases with which they were respectively concerned.

Dr. Teall then opened the demonstration by giving a brief explanation of the structure of the highly complicated area portrayed in the large model of the Assynt district of the N.-W. Highlands. This model is illustrated by a series of photographic enlargements and by specimens of the typical rocks, both of which are placed conveniently for reference to the model. Professor Watts, the President, proposed a vote of thanks to Dr. Teall at the close of his demonstration.

Mr. Cantrill then directed attention to the Ammanford Map and Section, pointed out that the district lies on the north-western margin of the South Wales coal-field, and is one of the richest of the anthracite mining-grounds. The oldest and most highly-disturbed rocks, the Cambrian and Ordovician, lie on the north-western margin of the area, while the newest and least inclined are to be found on the southern. The high dip prevailing among the older beds enables a visitor to Llandilo to walk from Upper Arenig Rocks across Llandilo Flags, Wenlock and Ludlow, Old Red Sandstone, Carboniferous Limestone, and Millstone Grit to the Lower Coal Series, in a distance of only three miles. Several lines of unconformity and disturbance were indicated on the map; the greatest being that between the Ordovician and Silurian, an unconformity accompanied by faulting, in consequence of which the Bala and Lower Llandovery rocks of the north bank of the Towy are missing on the south. Another great disturbance runs along the Old Red Sandstone outcrop, with the result that a string of Carboniferous Limestone outliers has been thrown down along the valleys of the Cennen and the Gwendraeth-fâch.

The glacial phenomena—striæ, transported boulders, and sheets of boulder-clay—show that the whole district was buried under ice, streaming from central Wales, which pressed southward through every gap in the main escarpments.

Specimens of the various rocks and their fossil-contents were displayed in the cases, together with some photographs which would convey a notion of some of the characteristic scenery of the district.

Mr. Dixon, after mentioning the sequence of formations exposed in the Swansea and Gower districts (1 in. to the mile, sheets 246 and 247), described some of the points of interest illustrated by specimens exhibited in the cases. The oldest rocks are the Ludlow Beds of Cefn-y-Bryn, which were first detected by Mr. Tiddeman, and from which some characteristic fossils have been obtained. They are generally followed immediately, and obviously unconformably, by Upper Old Red Sandstone, consisting of sandstones, termed Brownstones, below, and of conglomerates above, both made up largely of quartz and red jasper detritus, fine or coarse. The red jasper fragments, though now presenting a comparatively uniform appearance, have really been derived from a variety of rocks which have been reduced to their present state by complete silicification and reddening with hematite. As similar processes are known to be taking place to-day under desert-conditions it is suggested that the conversion to red jasper was effected by the similar conditions which prevailed in Old Red times.

The Carboniferous Limestone Series, though strikingly similar on the whole to that of the Bristol district visited by the Association the previous year, presents some points of difference. The limestone underwent considerable dolomitisation, first while still within reach of Carboniferous sea-water, which gave rise to "contemporaneous" dolomites, and afterwards in Triassic times, when underground magnesian waters effected a considerable amount of "vein-dolomitisation," especially in the walls of fissures. The different effects of these two types of alteration on various limestones were briefly mentioned.

The Millstone Grit Series is of interest in consisting chiefly of shales, and in including at the base a group of radiolarian cherts. Of the Coal Measures some of the most important problems will be dealt with by Dr. Strahan in a forthcoming memoir, but some characteristic fossils, both plant and animal, were exhibited and a conglomerate from the Pennant Series, with fragments of mica-schist and coal, was referred to as coming from the quarry where Logan first noticed coal-pebbles in a Coal Measure sandstone.

After the great post-Carboniferous earth-movements Triassic rocks were deposited, probably over most of the district, though their former presence is generally evidenced now merely by the reddening of many of the Carboniferous rocks, such as the Millstone Grit shales, which have been ground for red paint at Port Eynon. Finally, light is thrown on the last stages of the geological history of the district by the raised beach, the bone-caves, the glacial deposits, and the submerged forest, the first having been shown by Mr. Tiddeman to have been formed before the glacial period, and the last indicating a considerable submergence in comparatively recent times.

In addition to the specimens a number of photographs illustrating the scenery and geology of the districts were on view.

Mr. W. A. E. Ussher then gave a short exposition of the case containing the exhibits of the "Plymouth and Liskeard" Memoir, Sheet No. 348. To this district Mr. Ussher recently conducted a party of the Association. (See *ante*, p. 78).

Mr. MacAlister delivered a few remarks on the Geology of the principal mining region of the West of England. This is the district comprised in the recently published 1-inch map 352, which includes the towns of Truro, Falmouth, Camborne and Redruth. The rocks of the region include greenstone, granite, elvan, mica trap and palæozoic sediments in which the igneous rocks were intruded.

Mr. Hill is responsible for the elucidation of the geology, and the new map shows extensive modification from that of the original survey by De la Beche in 1839.

In the old map most of the area was indicated as Devonian, only a small portion east of Gerran's Bay being coloured Lower Silurian, which corresponded to and is now known as Ordovician. To these beds Mr. Hill has given the name Veryan. According to the new map the Devonian rocks do not come south of an east and west line drawn between Porth Towan and Probus. The rest of the region, formerly coloured Devonian, is now believed to be not only older than the Devonian, but represents a descending sequence, of which the Veryan Group is the upper member, while the Portscatho, Falmouth and Mylor groups succeed it in the order named. To complete the stratigraphical history it should be mentioned that in the adjoining district to the east (Porth Luney), described by Mr. Clement Reid, Upper Silurian fossils have been found which Messrs. Upfield Green and Davies Sherborne have proved beyond doubt to be of Wenlock age.

The Devonian rocks are resting unconformably on the Lower Palæozoics, and their occurrence as conglomerates in the Meneage peninsula shows that the Devonian strata were formerly more widely represented in South Cornwall.

Before the intrusion of the granites, elvans, and mica traps, the region was disturbed by pre-Devonian and post-Carboniferous crustal movements resulting in overfolding and shearing of the sedimentary rocks with development of slates, crush-breccias, and other dynamically formed rock types. The greenstones, all of which were intruded before the Carboniferous movements commenced, have likewise been affected by the general disturbances. They were originally dolerites, gabbros, and basalts, and are now epidiorites or metamorphosed rocks in which garnet, epidote, and other minerals are developed.

The granite is the most important igneous rock in the region. According to Mr. Teall it was intruded at the close of, and as a relief to, the post-Carboniferous movements to which the deformation of the sedimentary rocks is mainly due. The tin and copper ores of the region, which for centuries have been of such importance in the west country, were derived directly from the granite magma in the final phases of its consolidation. The metals were extracted from the magma by means of fluorides, borides, and steam, and deposited largely under pneumatolytic conditions in fissures in the granite and in the contact altered rocks (andalusite and biotite schists and hornfelses) of the metamorphic zone surrounding it. The lodes constitute a mixed type which may be described as cassiterite veins characterised by the presence of large amounts of copper ores and other sulphides.

The presence of tourmaline and wolfram suggests an affinity with the sub-group of which similar veins in Tirpersdorf, Bohemia, are typical, so that on the whole the lodes of the region present a variety of features of interest from the point of view of the genesis of the minerals.

In demonstrating the exhibit arranged to illustrate the Geology of the Land's End district (maps 351 and 358), described by Mr. Clement Reid and Dr. J. S. Flett,* Mr. T. C. Hall pointed out that the area was of special interest owing to the facilities it offered for the study of contact-metamorphism, and that the west of Cornwall has long been known as a typical region for phenomena of that kind. The killas, which mainly belongs to Mr. Hill's Mylor division of the Lower Palæozoics, has been altered by the intrusions of both granite and greenstone, but, as pointed out in the Memoir, the alterations produced in each case are of an entirely different kind, and they can be easily distinguished. The granite aureole is principally occupied by spotted slates which pass, in the inner zones of the aureole, into hard splintery black or dark-brown hornfelses in which all traces of spotting are often nearly or completely effaced by the extensive recrystallisation which the rocks have experienced. The speaker here called particular attention to a specimen of cordierite-hornblende-hornfels from near Kenidjack Castle, St. Just, as no finer cordierite rocks than those from this locality are known in Britain. Attention was also drawn to a specimen of granite enclosing a fragment of slate, as these enclosures exhibit the extreme phase of alteration of the killas, and contain such minerals as cordierite, andalusite, sillimanite, spinel, corundum, tourmaline, etc. The alteration of the killas by the greenstone was illustrated by specimens of adinole and spilosite.

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* Memoirs of the Geological Survey. "The Geology of the Land's End District," by Clement Reid, F.R.S., and J. S Flett, M.A., D.Sc. (1907.)

The greenstone, a name given to the much strained and altered basic igneous rocks quite unlike any of the later intrusions which cut them, have themselves been altered by the granite, and, where they occur in immediate contact with that rock, are converted into splintery diabase-hornfelses, specimens of which were exhibited. Other specimens showed that the greenstone also sometimes exhibits spotting similar to that so well seen in the contact-altered sediments. A specimen of garnetiferous greenstone illustrated the pneumatolytic modifications produced by the granite.

In referring to the granite it was stated that a characteristic feature of the Land's End mass is the coarsely porphyritic character of the rock due to the presence of crystals of felspar up to several inches in length, as seen in one of the specimens shown, and mention was made of the interesting fact, brought out during the survey of the area by Mr. Clement Reid, that the mass is not all of one age or type, but includes an area of about seven square miles of a fine-grained granite of somewhat later date. An exhibited specimen of this finer granite claimed attention for a large crystal of pinite which it contained. This mineral is widely disseminated through the Land's End granites and elvans, and represents an alteration product after cordierite.

The coarse pegmatite which is distributed as veins and patches in the granite, towards its margin or irregularly dispersed through its outcrop, was illustrated by two specimens, one of which showed the large amount of schorl frequently present in these rocks. The pneumatolytic modifications of the granite, produced by vapours which emanated from it at a time following its injection but anterior to its complete cooling, were seen in specimens of schorl-rock and greisen.

Among the exhibited specimens of elvan, a name given in Cornwall to the long narrow dykes of quartz-porphyry of slightly later date than the granite masses, was a specimen of the well-known coarsely-porphyritic dyke of Prah Sands containing many crystals of pinite, and a specimen from Wheal Herland showing tourmalinisation: a corresponding pneumatolytic change to that which takes place in granite in the production of schorl-rock.

The Tertiary strata were illustrated by specimens of sub-angular chalk-flint and greensand-chert from the gravel deposit which occurs near Marazion, and which is probably of Eocene age, and by a series of fossils from the well-known Pliocene deposit of St. Erth. In this connection a specimen of the Wolf Rock phonolite was shown and mention made of the fact that the mass is probably of Tertiary date, for, unlike the Palæozoic igneous rocks of Cornwall, it is neither altered nor sheared. It was first described by Allport, and is of considerable interest as being the best example of a phonolite known to occur in Britain.

The next cases to be examined were some recent additions to the fossil collection which were explained by Mr. H. A. Allen. Attention was drawn to a series of fossils from Speeton in Yorkshire, collected zonally by Mr. C. G. Danford; examples are exhibited from the Kimeridge clay (zone F) upwards to zone A or *Belemnites minimus* beds. Some of the belemnites had been split longitudinally in order to show the difference in the apical termination of the alveolar cavity between the groups *B. lateralis* Phill., and *B. brunsvicensis* Stromb.[*]

In the same case is a series of specimens to illustrate the various zones of the Carboniferous Limestone as divided by Dr. A. Vaughan,[†] *viz.*,

D, or zone of *Dibunophyllum* aff. *turbinatum*.
S, or zone of *Seminula ficoides*.
C, or zone of *Syringothyris* aff. *laminosa*.
Z, or zone of *Zaphrentis* aff. *phillipsi*.
K, or zone of *Cleistopora* aff. *geometrica*.
M, or zone of *Modiola lata*.

Mr. Carruthers has shown[‡] that the zone fossil *Zaphrentis* aff. *phillipsi* does not occur in these beds, consequently it will be well to refer to the zone Z as the Z, or *Zaphrentis*-zone.

Another exhibit comprised a selection of bones of mammalia from a cave at Clevedon, Somerset, presented by a member of the Association, Dr. H. C. Male, and by Mr. G. E. Male; some interesting plants and crustacea from the Coal Measures of Derbyshire presented by Dr. L. Moysey; Pliocene and Pleistocene Mammalia including a femur of an elephant dredged from the Forest Bed off the Norfolk coast; and enlargements of photographs of *Synhelia*, *Micraster*, and *Cyphosoma*, by a member of the Association (Mrs. Teall).

This most interesting visit concluded with a cordial vote of thanks to the officers of the Geological Survey and Museum, moved by the President. Mr. Howe in responding hoped that the members would from time to time come and visit these temporary exhibits.

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[*] Danford, C. G., *Trans. Hull Geol. Soc.*, V, 1906, pp. 1-14.
[†] Vaughan, A., *Quart. Journ. Geol. Soc.*, lxi, 1905, pp. 181-307.
[‡] Carruthers, R. G., *Geol. Mag.*, vol. v., p. 63, February, 1908.

EXCURSION TO LEIGHTON BUZZARD.

SATURDAY, APRIL 4th, 1908.

Director : G. W. LAMPLUGH, F.R.S., F.G.S.
Excursion Secretary : A. C. YOUNG.

Report by THE DIRECTOR.

On reaching Leighton Buzzard about 2 p.m. the party, reinforced by members of the Hertfordshire Natural History Society, and numbering in all about twenty, walked out to the Shenley Hill sandpits, passing on the way a small brickyard in the Gault from which both Lower and Upper Gault fossils have been obtained by Mr. A. J. Jukes-Browne.

The Lower Greensand which emerges from beneath the spur of Gault and Boulder Clay forming Shenley Hill is dug on the south-east side of the hill in a succession of extensive pits which are practically conterminous with each other. The principal object of the excursion was to examine the richly fossiliferous horizon discovered in 1902 at the top of the Lower Greensand in these pits, and described in the following year by Messrs. G. W. Lamplugh and (the late) J. F. Walker.*

The fauna of this horizon, particularly rich in brachiopods, differs from that of any deposit hitherto found beneath the Gault, and presents a facies usually associated with the Upper Greensand in England, though with some feature at present peculiar to itself. The mode of occurrence of the fossil-bearing rock is shown in the accompanying illustration (Fig. 34), reproduced by permission of the Council of the Geological Society, from the above-mentioned paper.

The party first examined the most southerly workings, known as "Garside's Pit" (see ground-plan, Fig. 2, of the paper above referred to), but found the most important portion of the section obscured by slips and down-wash of Gault clay. The position of the fossil-band was, however, demonstrable in one part of the section, and some blocks of the fossiliferous limestone were found on the spoil-bank, which, under the hammers of the visitors, yielded numerous examples of the characteristic organisms, including the curious *Terebrirostra lyra*, var. Numbers of fine specimens were also still more easily obtained from a bag produced by one of the quarrymen, who mentioned that the late Mr. Walker had been a buyer of all that could be obtained at so much *per pound-weight.*

The Director stated that during the working back of this pit in 1904-1906 (subsequent to the publication of his previous

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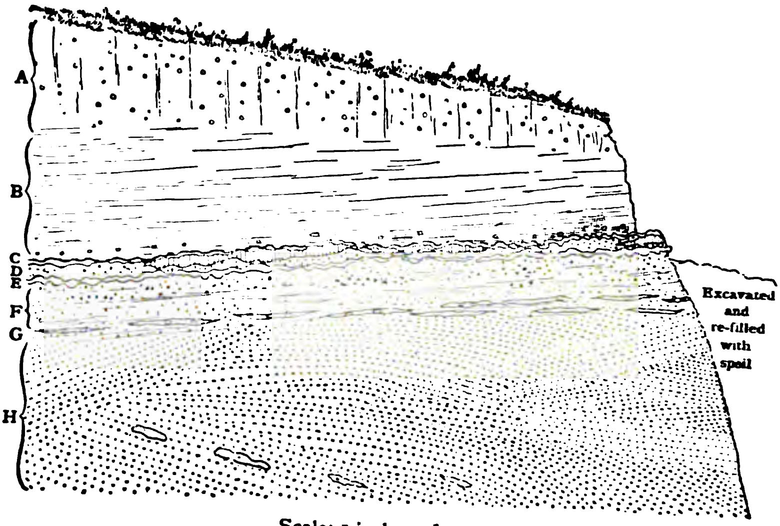
* *Quart. Journ. Geol. Soc.*, vol. lix (1903), pp. 234-265.

Fig. 34. SECTION AT THE NORTHERN END OF HARRIS'S SAND-PIT, SHENLEY HILL.—*G. W. Lamplugh.*



Scale:- 1 inch = 10 feet.

Reproduced by permission of the Council of the Geological Society of London.

Brown clayey soil with small stones ... 1 ft.

A. Bluish-grey Boulder Clay composed of rearranged Gault speckled with small pieces of chalk, flint, iron grit, and a few pebbles of quartz, etc. 2 to 6 ft.

merging downwards into

B. Gault: bluish-grey shaly clay in the upper part and dark blue below; with a few pyritous clay-stone nodules just above the base ... ... 4 to 7 ft.

C. Irregular band of iron grit with smooth worn wrinkled surface: usually dark liver-red, but in places crimson 1 to 3 ins.

D. Ochreous or greenish-yellow loamy sand, grit and breccia; replaced here and there by lenticles of pale flesh-coloured or yellowish gritty limestone full of fossils ... ... 1 to 2 ft.

E. Undulating iron grit band, as a rule sharply defined, but in one place approaching the upper band and there becoming lenticular and confused ... 2 to 3 ins.

F. Greyish greensand moist and loamy, with clayey streaks and lenticles of pebbly grit ... ... 2 to 3 ft.

G. Lenticles of dark-red and ochreous iron-grit with included nodules of sandy pyritous clay-stone; streaks of fuller's earth, dark clayey greensand, and ochreous loam below; forming a well-defined band capping the "silver-sands" 1 to 1½ ft.

H. "Silver-sands": clean white or iron-stained sand, strongly cross-bedded, with sporadic masses of ironstone sometimes containing traces of wood ... ... 10 to 15 ft. seen.

description) a bed of glauconitic sand had set in between the Gault clays and the upper ironstone (c) which covers the lenticles of fossiliferous limestone, and had increased westward to a thickness of 5 ft. before the excavation in this direction ceased. He had also seen in one place a sea-worn crag of the ironstone, a few feet across, on which small oysters and serpulæ were adherent, protruding upward for 3 ft. or 4 ft. through the glauconitic sand so that its top was covered by the Gault clay. He remarked that this afforded evidence that portions of the sands had been cemented into ironstone before the deposition of the Gault, and also that there had been erosion of the lower beds by currents before the Gault clay was laid down. He preferred to regard the glauconitic sand as the true basement bed of the Gault, and to class the beds below it with the Lower Greensand. From the glauconitic sand he had collected a few terebratulæ, small oysters, serpulæ, fish-teeth, and belemnites, but had failed to find any ammonites: nevertheless he suspected that this bed represented the horizon of *Acanthoceras mammillatum*, in which case the fossiliferous limestone represented a somewhat lower horizon. He suggested that the difficulties which had arisen in the correlation were mainly due to the fact that we knew of no other fossiliferous representative of this stage in England.

The party next examined the section in Harris's Pit where the base of the Gault was in one place well exposed, with the ironstone floors beneath, but without happening to show any of the limestone lenticles.

The most northerly pit of the series, know as "Chance's," was then visited. This pit is no longer worked, but through the kindness of the proprietor, Mr. Joseph Arnold, who now joined the party, an excavation had been made at a spot where the fossiliferous rock was present, and some chunks of it were dug out by the workmen in the presence of the visitors, who were thus enabled to satisfy themselves as to its position beneath the ironstone floor. The rock was rich in fossils, and yielded, among other forms, a good specimen of the rare *Terebratella hercynica.*

The weather up to this time had been fine, but now the storm-clouds gathered; and while the members were traversing the excellent sections of current-bedded white or brilliantly stained sands in adjacent pits worked by Mr. Arnold, they were driven hastily to shelter by pelting rain. The shower lasted long enough to prevent the projected visit in the evening to the Grovebury Siding pits south of Leighton, where the junction of the Gault and Lower Greensand is again revealed, but does not present the same features as at Shenley Hill.

Under the circumstances the proceedings were brought to a close by tea at the "Swan" Hotel, Leighton, where a hearty vote of thanks was accorded the Director, proposed by the President and seconded by Mr. H. Kidner, on behalf of the Herts. Nat. History Society.

The party afterwards returned by the 7.2 p.m. train to London.

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THE GEOLOGY OF THE BERWYN HILLS.

By J. LOMAS, A.R.C.S., F.G.S.

THE Berwyn area is not strictly defined, but we may take it as the country enclosed by the ridge of high ground running westward with the River Dee from Chirk to Corwen, then south-west through Llandrillo to Lake Vyrnwy, and eastwards to the hills extending from Llanymynech to Llangollen.

Structurally it is a dome, the middle of which has been denuded, leaving a rim of hills which, on the north, west, and south-west, show an unbroken contour of over a thousand feet above sea-level. The south-east and easterly margins, though lofty as a whole, have been cut into deeply by the drainage systems of the Ceiriog, Morda, and Tanat Rivers.

The highest ground culminates in the north-west corner of the area in Cader Berwyn, 2,716 ft., and this is well supported by Moel Ferna, Cader Fronwen, Mynydd Tarw, Post Gwyn, and other hills clustering round, all of which are over 2,000 ft. high.

The drainage of the Berwyns is gathered into two main streams, the Ceiriog and the Tanat. Both these rivers rise in the high ground on the west, and traverse the district from W. to E. In its upper reaches the Ceiriog runs against the dip of the strata and over three bands of igneous rock, forming a series of beautiful falls.

About Llanarmon Dyffryn Ceiriog it runs roughly parallel to the strike of the slates, but soon after passing that place it enters a deep gorge, cuts through the igneous bands again, this time with the dip, and after passing Llansantffraid Glyn Ceiriog it opens out into a broad valley. Before reaching Chirk it once more flows through a gorge where it cuts through the Carboniferous Limestone. Before reaching the Triassic plain it turns northwards and soon joins the River Dee.

It is probable that the upper and lower parts formerly belonged to two separate systems, the first part above Llanarmon D.C. being tributary to the Severn drainage until it was captured by the Dee. The beheaded consequent now begins on the south side of the pass near Pensarn and flows into the Cynllaith.

The Tanat does not appear to have suffered any such vicissitudes but preserves its course as a strike stream close to the boundary hills on the south. On its way it gathers up the waters of the Eiarth, Rhaiadr, Irwch and Cynllaith, all of which join the main stream on its left bank and drain the middle part of the dome. It flows into the Vyrnwy at the south-east corner near Llanymynech. For a part of its course the Tanat forms the boundary between a detached part of Denbighshire and Merionethshire. These counties exchange plots on each side of the river, which indicate the changes which the river has undergone since the county boundaries were established. Swampy "oxbows" alternating on each side of the stream tell the same tale.

The Morda rises in the Carboniferous heights on the east. It begins as a strike stream, follows the junction of the Carboniferous Limestone and overlying sandstones through a narrow defile 500 ft. deep, then turns eastward along the dip until it reaches the Shropshire plain, where it bends southward to join the Vyrnwy and the Severn drainage.

GEOLOGICAL STRUCTURE.

The geological structure of the Berwyns was first described by Sedgwick in 1845,[*] and the generalised plan he gives of the chief lines of strike are in the main correct. Jukes, in Ramsay's "Geology of North Wales,"[†] gives fuller details. He describes the various formations which occur in the area, but in the map which accompanies the Memoir he hesitated to draw lines separating the various divisions of the Lower Silurian series.

Since that time very little systematic work has been done on the pre-Carboniferous rocks.

One little portion about Glyn Ceiriog has recently been mapped by Dr. T. Groom and Mr. P. Lake,[‡] and we must wait until the other areas have been similarly treated before we can say that the Berwyns are satisfactorily known.

The Carboniferous rocks on the east have received more attention, and they have been very fully described by Messrs. G. H. Morton,[§] D. C. Davies,[||] the Rev. J. Yates,[¶] Dr. Wheelton Hind, Mr. G. T. Stobbs,[**] and others.

With so little that is known and so much to learn regarding the older rocks, little can be done beyond pointing out problems to be solved, and it is better to do this rather than express opinions on imperfect data. If read in this spirit the remarks which follow may at least provide matter for observation and discussion.

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[*] *Quart. Journ. Geol. Soc.*, vol. i, 1845, p. 12.

[†] *Mem. of Geol. Surv. of Great Britain*, vol. iii, 1866.

[‡] Abs. *Proc. Geol. Soc. of London*, No. 863, May, 1908. Only an abstract of the paper has been issued up to the present.

[§] "The Carboniferous Limestone and Cefn-y-Fedw Sandstone of the country between Llanymynech and Minera, North Wales," D. Boyne, London, 1879.

[||] "On the Discovery of Fossils in the Millstone Grit near Oswestry," *Rep. Oswestry and Welshpool Nat. Field Club*, 1860, p. 41.

[¶] "Observations on the Structure of the Border Country of Salop and North Wales, and of some Detached Groups of Transition Rocks in the Midland Counties," *Trans. Geol. Soc.*, Series 2, vol. ii, p. 237.

[**] "The Carboniferous Succession below the Coal Measures in North Shropshire, Denbighshire, and Flintshire," *Geol. Mag.*, Dec. v, vol. iii, 1906.

According to Jukes* "the Lower Silurian rocks of the Berwyn Hills form an imperfect dome, or rather an irregular and broken curve, the anticlinal axis of which follows a bent line about 24 miles in length. The eastern end of this dome has been cut away by denudation, and is overlapped by the Carboniferous Limestone west of Oswestry. From the limestone the axis runs by Llangadwaladr, Craig-y-Glyn, and Llangynnog, to the base of the Wenlock series, a little north of Garthbibio." He regards the Berwyn anticline as one of a series which affect North Wales, and on p. 215 of the same Memoir he states: "Taken in connexion with each other, the three districts of Merionethshire, the Berwyns, and the Longmynd form three great anticlinal curves with synclinal bends between; but in the middle boss of the Berwyns the upward bend has not been sufficient to bring the Lingula Flags and the Cambrian rocks to a level where they might be exposed by the denudation of the overlying Silurian strata."

The hills forming the northern and western margins of the dome dip into synclines, which bring in the upper beds of the Bala series and the Denbigh grits.

At the south-west corner near Hirnant a similar syncline is seen, but the beds are reversed and present an overfold towards the interior.

The dome may be regarded as the result of cross folding. The first folding probably took place in Devonian times, when what is now the axis of the dome was ridged up into an anticline running N.E.—S.W.

Complementary to this ran synclines, one on the north-west, parallel with the Bala fault, and the other running on the south-east through the Llanfyllin area. The axis of folding is Caledonian in direction.

Then followed a period when denudation reduced the anticline, leaving the synclines standing as ridges of high ground. We know that the whole of the Silurian was removed from the anticline before the Carboniferous Limestone was laid down, for it rests on the Silurian rocks in the north, and overlaps older formations where it crosses the axis of the dome (Fig. 35).

In post-Carboniferous times folding again took place along a north and south axis parallel to the Pennines. The anticline of the Pennines dips into a syncline under the Cheshire plain, and then rises towards an anticline over what is now the centre of the Berwyn dome. At this period the Carboniferous rocks on the east of the Berwyns were tilted and received their easterly dip.

Now let us consider the effects of a wave progressing from the east and meeting the rocks already folded in a N.E.-S.W. direction. The synclines of the Berwyns being solid and resistant would act as horsts, against which the north and south wave would be

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* Ramsay's "Geology of North Wales," Edit of 1866, p. 212.

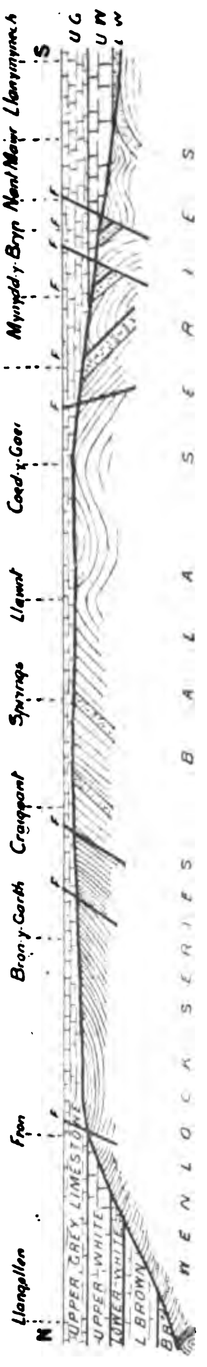

FIG. 35.—DIAGRAMMATIC SECTION FROM LLANGOLLEN TO LLANYMYNECH SHOWING OVERLAP OF CARBONIFEROUS LIMESTONE ON WENLOCK AND BALA BEDS.—*J. Lomas.*

deflected as a left-handed torse. The strike of the beds clearly shows this movement, and the over-fold in the south-west corner may have resulted from the torsional effects set up against the southern syncline. Where the north and south fold infringed on the northern horst near Cader Berwyn we find a series of virgating faults which have thrust back the various beds towards the middle of the dome. Where anticline crossed anticline we should expect an upward bulging of the strata, and in this region the lowest beds have been brought within the range of denuding forces.

It is along the anticlinal axis of Caledonian folding that most of the igneous rocks of the Berwyns occur, and one cannot help surmising that the lessened pressure due to uplift may have left areas into which the deep-seated rocks under the synclines would be thrust. It is significant that the igneous rocks never invade the synclinal areas. They are in greatest force near the centre of the dome, where they take the form of compact felsites, whereas, on the margins where the beds are dipping towards the synclines, there is a series of thin bands' which follow the bedding with remarkable regularity, and as they are fragmental in places they have been described as contemporaneous volcanic ashes.

It is highly probable that movement on an important scale has taken place along the same lines in later times, for the Bala fault in its extension towards the east displaces the Carboniferous Limestone at Caergwrle, and the same line of dislocation continued under the Trias of the Cheshire plain is met with again on the flanks of the Pennines.

Post-Triassic folding parallel with the Pennine axis is seen in the Vale of Clwyd and in the Cheshire and Shropshire areas, and traces of this may perhaps be found in the Berwyns.

The Carboniferous rocks from Llanymynech to Llangollen are disturbed by a series of important faults, having an east and west trend. This means a folding parallel with the Armorican axis, and it may be correlated with the movements which caused the Carboniferous Limestone of Staffordshire to dip under the Trias of the Midlands.

In the north-east part of the area very few faults are recorded on the Survey Maps, but by patient mapping Messrs. Groom and Lake have shown that in the Glyn district numerous faults occur, the principal of which have an east and west trend. Some of these may be the continuations of those which have affected the Carboniferous Limestone.

The sheared condition of the rocks makes it evident that great movements have taken place, but we must wait for more detailed mapping before definite conclusions can be drawn.

LLANDEILO SERIES.

The lowest beds which occur in the Berwyns are the Llanrhaiadr Shales of Llandeilo age. They are well exposed in the neighbourhood of Llanrhaiadr-yn-Mochnant in the banks of the stream south of the church, on the roadside along the banks of the Rhaiadr, and in road cuttings leading from Llanrhaiadr to Craig-y-Glyn.

The shales are nearly black, and break into cuboidal masses which exfoliate into rounded pieces. They have been affected by cleavage to a very small extent. Numerous bands of grit are interbedded with the shales, and when they are crumpled into folds, as along the course of the Rhaiadr, the grit bands are sheared into lenticles at anticlines while they persist as continuous bands in the synclines. So far the shales have yielded no fossils.

At Craig-y-Glyn they are seen to dip under limestones 400 to 500 feet thick, which dip 25° S.E. In their lower parts the limestones are laden with *Asaphus tyrannus*, encrinites and corals, and in their higher portions *Trinucleus concentricus*, *Acidaspis*, *Leptæna sericea*, *Orthis turgida*, and other fossils occur. The insoluble portion of the limestone after treatment with hydrochloric acid consists of zircon, ilmenite, kyanite, quartz, orthoclase, and diopside.

The Upper Llandeilo Shales succeed the limestone conformably, and these again give place to beds of Bala age.

Bands of igneous rocks occur at various horizons, both in the

Llandeilo and Bala beds. These will be considered later when the various sedimentary members of the series have been passed in review.

BALA SERIES.

With our present knowledge it is impossible to give the exact limits of the Llandeilo and Bala formations. The beds, however, are by no means unfossiliferous, and systematic collecting would soon lead to important results. Generally, it may be taken that the soft black shales in the middle of the area are Llandeilo, and the Bala forms a ring all round them.

The Bala slates, as a rule, are imperfectly cleaved, but in the neighbourhood of the igneous rocks at Cader Berwyn and Craig Rhiwarth, near Llangynog, workable slates are obtained. Bands of grit are interbedded with the slates at various horizons, some of which are very massive, and they have been quarried for road metal.

In the Glyn area Messrs. Groom and Lake recognise the following sub-divisions of the Bala and overlying Silurians. Thanks to these workers, we now have a typical district well described, and this will serve for comparison with other areas.

The sequence, according to the authors,* is as follows:

Denbighshire Slates.		
Ty-Draw Slates, with *Monograptus marri*		TARANNON and LLANDOVERY.
Fron-Frys Slates, with *Pentamerus undatus*, *Meristina* cf. *crassa*, *Nidulites favus*, etc.		
Glyn-Valley Series	(*b*) Glyn Grit and Limestone	BALA.
	(*a*) Ddolhir Beds, with *Phyilopora hisingeri*, *Ramipora hochstetteri*, *Trinucleus seticornis*, species of *Cybele*, *Cheirurus*, *Remopleurides*, and numerous cystids, corals, brachiopoda, etc.	
Graptolite-Slates, with *Dicellograptus elegans*		
Gap.		
Pandy Series.	(*e*) Pen-y-Graig Ash	
	(*d*) Bryn-Beds, with *Tetradella complicata*, *Phacops apiculatus*, *Trinucleus concentricus*, *Triplesia spiriferoides*, *Rafinesquina ungula*, etc.	
	(*c*) Craig-y-Pandy Ash	
	(*b*) Teirw Beds, with *Lingula tenuigranulata*, *Bellerophon nodosus*, *Asaphus powisi*, etc.	
	(*a*) Cwm-Clwyd Ash	

The Teirw Beds are correlated with the Roman Fell group of the Lake District, and the Bryn Beds with the Sleddale Beds. An important fault running along the strike of the beds has been shown to exist between the Graptolite-slates and the overlying Ddolhir Beds. The Bala Limestone is well exposed in a quarry near Ddolhir. It is divided by thin shales into beds, and differential shearing along the shales has drawn out the limestone into lenticles. Under the microscope the rock is finely granular, and shows that crushing has affected its most intimate structure. Fragments of shells, encrinite stems and corals are abundant, and in places great bunches of Halysites occur.

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* Abs. *Proc. Geol. Soc. of London*. No. 863, 1908.

Outside the sheared zone the beds have suffered decalcification, and the fossils, which are found in great profusion, mostly occur as casts.

Near Milltir-gerig the limestone is phosphatic, and has been worked in tunnels, but quite close to the works where the limestone crosses the stream and causes a little waterfall, it is decalcified.

The same features are observed all round the outcrops, and it is only in certain localities that it appears as a true limestone.

Lower Llandovery Beds have never been recorded from the Berwyns, but the Upper Llandovery is represented, according to Messrs. Groom and Lake, in the strata intervening between the Bala Limestone and Tarannon shales. They can be readily examined in the old slate quarries west of the Selattyn road. The Ordovician rocks are everywhere bordered by a band of Tarannon shales, which lead upwards to the Denbighshire grits and slates of Wenlock age.

SILURIAN.

Denbigh Grits and Slates fill the synclines which exist as a ring round the dome. The sequence is broken or rather concealed under the Carboniferous rocks, and in the south-east corner they have been denuded.

Before the uplift of the anticlinal areas they must have covered the whole of the Berwyn area.

At Glyn very extensive slate mines are now being worked in this formation, and along the same strike at Glyndyfrydwy and other places to the west quarrying operations are also carried on.

North and west of Llangollen the same beds come in in great force, rolling into a series of minor folds before rising to the anticline of Cyrn-y-Brain.

About Llangollen and in other restricted areas they are fossiliferous, containing such forms as *Orthoceras primævum ; O. ventricosum*, *Cardiola interrupta*, *Actinocrinus pulcher*, a few Graptolites and other forms.

CARBONIFEROUS LIMESTONE.

The basement beds of the Carboniferous series lie unconformably on the Denbigh slates on the line of a minor anticline about two miles north of Llangollen. The strike of the underlying slates is east and west, and that of the Carboniferous north and south. Morton gives the thickness of the basement beds as about 300 ft. They are not well exposed, but can be seen at the foot of the Eglwyseg Rocks near Dinbren Uchaf, and the red colour of the soil in the adjoining fields indicates their extent. They consist of dark red sandstones and conglomerates, which contain angular and rounded fragments derived from the Silurian rocks.

Immediately above the basement beds the Carboniferous Limestone rises in the great scarp of Craigiau Eglwysegle, and proceeding eastwards with the dip we traverse the whole succession of the Carboniferous rocks so far as it is developed in North Wales. The photograph by Mr. G. Bingley, which is reproduced as Plate XXV, gives a view of the escarpment.

Mr. G. H. Morton classifies the various beds according to their lithological characters, and the following table* may be taken as showing the order which is maintained throughout the district. The thickness only applies to the Llangollen area.

TABULAR VIEW OF THE CARBONIFEROUS LIMESTONE AND CEFN-Y-FEDW SANDSTONE IN THE COUNTRY AROUND LLANGOLLEN.†

		Feet.	
Cefn-y-Fedw Sandstone.	Aqueduct Grit or Upper Sandstone and Conglomerate	70	Upper Cefn-y-Fedw, Dee Bridge, or Millstone Grit Series.
	Upper Shale	30	
	Dee Bridge Sandstone	30	
	Lower Shale, with Fire Clay and Bands of Limestone	18	Middle and Lower Cefn-y-Fedw, or Yoredale Series.
	Middle Sandstone	200	
	Cherty Shale	50	
	Lower Sandstone and Conglomerate	250	
	Sandy Limestone	75	
Carboniferous Limestone.	Upper Grey Limestone	300	Upper Carboniferous Limestone.
	Upper White Limestone	300	
	Lower White Limestone	120	Lower do.
	Lower Brown Limestone	480	
		1923	
	Upper Old Red Sandstone	300	
	[=Carboniferous Basement Beds.]		

Morton also gives full lists of the fossils collected from each sub-division, and these have formed the basis of a new classification based on palæontological grounds by Dr. Wheelton Hind and Mr. J. T. Stobbs.‡

During a recent examination of the beds, in which Dr.

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* "The Carboniferous Limestone and Cefn-y-Fedw Sandstone of the Country between Llanymynech and Minera," p. 25.

† See the section, Fig. 37, p. 499.

‡ *Geol. Mag.*, Dec. v, vol. iii, 1906, p. 385.

Wheelton Hind and Dr. A. Vaughan took part, data were obtained which enabled these workers to zone the limestones and overlying beds according to the type sections described by Dr. Vaughan in the Avon sequence. The Tournasian, as developed in the typical Avonian section is not represented. The district was not submerged until the beginning of Viséan times. It is interesting to note that, when depression began to take place in North Wales, movements were also in progress in the south, which gave rise to an unconformity. The lowest beds in the Llangollen district are found to be mainly of D1 age, but they may also embrace a part of the Seminula zone. About the top of the Lower White Limestone of Morton the zone of D2 comes in and extends to the summit of the Upper Grey Limestone.

The Sandy Limestone has suffered decalcification, but it contains a fauna characteristic of D3.

The Middle and Lower Cefn-y-Fedw Series are correlated with the Pendleside Series of Dr. Hind, and the overlying sandstones and shales with the Millstone Grit.

The Carboniferous Limestone attains its maximum thickness in the Eglwyseg rocks. At Fron-y-Cysyllte, on the south side of the Dee and only a few miles from Llangollen, the lower 600 ft. are unrepresented, and the Upper White Limestone rests directly on the Silurian. At Bron-y-Garth, Craignant,* Llawnt, and Treflach Wood the Upper Grey Limestone forms the base of the series, while the Upper White comes in again at Nant Mawr and Porth-y-Waen, and still farther to the south, at Llanymynech, the Lower White Limestone is developed. Thus, on proceeding southwards along the strike of the beds from Llangollen to Llanymynech we find an area in the middle where only the upper beds were deposited. This suggests that a ridge of land at least 600 ft. in height stood above the water when the lower beds were laid down. It is interesting to note that this ridge corresponds in position and direction with the anticlinal arch of the Berwyn dome. North of the ridge a bay ran up into the interior at least as far as Corwen, and another embayment existed to the south near Llanymynech. The section (Fig. 35, page 480) is not taken in a direct N. and S. line, but follows the westerly face of the Carboniferous escarpment. It represents the lie of the beds if we consider the limestones to be replaced in the positions they occupied before the displacements caused by the east and west faults The top of the Upper Grey Limestone has been chosen as a datum line from which the measurements of the various beds have been taken.

All along the strip of Carboniferous rocks the beds show a persistent easterly dip, and the higher members of the series crop out towards the east. Thus in the section (Fig. 35) which runs along the strike they are represented by horizontal lines.

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* The photograph by Mr. G. Bingley, which is reproduced as Plate XXVI, shows a large colony of *Lithostrotion irregulare* in the Carboniferous Limestone at Craignant Quarry. The scale in the photograph represents inches.

It is mentioned above that the sandy beds above the limestones have been decalcified, and represent horizons developed in the north of England as true limestones.

Morton* clearly had this in mind when he doubted in some instances whether they should be included with the Carboniferous Limestone or with the Cefn-y-Fedw Sandstones. Good sections are rarely exposed, but in the neighbourhood of Oswestry Racecourse at Underhill, and in Allinson's Quarry at Cwm Sych they have been worked mainly for the cherty bands which occur interbedded with the sandy beds. At Allinson's Quarry a rich fauna has been obtained with such forms as *Actinoconchus planosulcatus*, *Caninia campophyllum*, *Cyathaxonia*, *Productus concinnus*, and other fossils which characterise a D3 assemblage.

We have no proof that any part of the Berwyns has been under the sea since Carboniferous times. Newer rocks, including Coal Measures, Permian Sandstone and Trias, appear to the east, and only fifteen miles from Oswestry Rhætic and Liassic beds occur. It is highly probable that the Liassic sea washed the flanks of the eastern hills, but no trace of the deposits laid down are to be seen. What is concealed under the drift we do not know, but there is not wanting evidence which suggests that the patch of Lias near Whitchurch is only one of a series, and others exist under the glacial deposits of the Cheshire plain.

GLACIAL DEPOSITS.

Two distinct types of Drift are found in the Berwyn area. One resembles the accumulations spread over the lowlands of Lancashire and Cheshire, and indicates a transport of materials from the north, the other is exclusively of Welsh origin.

The Welsh Drift has a dark matrix and never contains marine shells. It is not, properly speaking, a clay, but consists mainly of finely comminuted slates mixed with sand. The boulders contained in the matrix are of Welsh origin, and in the Berwyns the parent rocks are always found to the west. This fact, in conjunction with the trend of the glacial striæ, points to a movement of ice from the high grounds forming the western borders, and boulders from the Arenigs still farther west prove that even these heights were overridden.

Considering the North Wales Drift as a whole we find that in the earlier part of the glacial period the mountainous land on the west became covered with ice. With the extension of the cold, glaciers were formed which crept down the low grounds as valley glaciers. Then they become confluent, and a radiant point was set up in the neighbourhood of the Arenigs from which the ice shed towards the Irish Sea on the north, towards St. George's Channel on the west, while eastwards great tongues debouched into the Cheshire and Shropshire plains and reached far into the Midlands.

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* *Op. cit.*, p. 122.

Then the northern ice, after invading the Irish Sea and filling it to overflowing, welled over the low grounds of Lancashire and Cheshire into the Midlands. It reached the coasts of North Wales and laid down the detritus which now forms the narrow coastal plain at the foot of the hills. The high ground near the coast offered too great a resistance for the northern invader to penetrate far into the interior, but where wide embayments opened to the north, as in the Vale of Clwyd, or gentle slopes reached down to the sea, as in the neighbourhood of Carnarvon, the ice overrode the country to a considerable extent, reaching as far as Denbigh in the Vale of Clwyd, and to the summit of Moel Tryfaen south of Carnarvon.

As no effective outlet was found towards the interior of the country the northern ice was compelled to split into two streams, one turning westwards over Anglesey and the other eastwards along the coast till it became confluent with the main stream progressing over Lancashire and Cheshire. The course of this component of the northern ice is marked by glacial deposits on the Welsh border hills, which in places reach an altitude of 1,300 ft.

With the approach of the northern invader the native Welsh ice shrank back to its mountain fastnesses and dwindled into small valley glaciers. On the North Wales coast at Penmaenmawr, and on the Border Hills above Ruabon the two drifts can be seen in conjunction. The northern always overlies the Welsh, thus proving their relative ages.

Clear signs of the retreat of the Welsh glaciers are seen in the valleys. Where they halted for a time moraines stretch across the valleys. The Clwyd, the Dee, the Ceiriog and the Tanat have all breached these mounds, and provided good sections for examination.

The northern ice moving southwards across the valley mouths of the Dee and Ceiriog obstructed the drainage. Hence lakes were formed which overflowed from one valley to another.

The district has not been critically examined for evidences of the existence of overflow channels, but one near Selattyn, with a valley floor 1,157 ft. above sea level, is an evident case.

In the heart of the Berwyns the deep valleys show very clear signs of glacial action. Besides the moraines mentioned above, hanging lateral valleys, caused by the overdeepening of the main channels, abound, and the sudden steepening of the valley slopes on descending to lower levels is very significant.

Standing on an eminence such as the Eglwyseg Rocks, and looking up the Dee Valley, we see inosculating spurs caused by the windings of the river. They descend from the mountains with even and gentle slopes down to about the 1,000 ft. contour. Then they fall suddenly and form a U shaped trough within the older valley. The spurs, too, which in an unglaciated country are sharp-pointed and run down to the floor of the valley are blunted and worn and present steep cliff-like terminations.

If we examine a contoured map we find that in some valleys the contours below 1,000 ft. are almost straight and show little or no indentations toward lateral valleys. Above this level the contours curve inwards with the valleys. With normal drainage the reverse is the case, and the contours are more deeply indented at the lower levels.

In the neighbourhood of Llangynog there are a number of waterfalls of sufficient importance to claim a name on the 1-inch Ordnance Map. These are Pistyll Gyfyng, or Pistyll Cwm Llech, Pistyll Cablyd, Pistyll Blaen-y-Cwm, and Pistyll Rhaiadr. All these are on the 1,000 ft. contour.

At Pistyll Rhaiadr a band of felsite occurs over which the water falls 210 ft., and the superior hardness of this band, compared with the neighbouring slates, may have had some influence in determining the position and persistence of the waterfall. No such disturbing factor can be adduced in the other instances for they are not associated with igneous rocks.

The evidence seems to be irresistible that the ice which filled the valleys exerted a powerful erosive action and has deepened some of them to the extent of 300 to 400 ft.

In the highest ground at Craig Berwyn and Moel Sych, the beautiful cirques with steep cliffs over 600 ft. high may also be cited as proofs of glacial erosion.

Llyn Llyn Caws, a dark and gloomy lake, nestles under the steep crags of the Moel Sych cirque.

The northern drift consists of brown boulder clay with intercalated and irregular bands of sands and gravels. Speaking broadly the Boulder Clay is characteristic of the lowlands, but in places it is found to a height of 800 ft. The sands and gravels come in with greater force in the higher grounds, where they form great hummocky mounds or eskers which reach an altitude of 1,300 ft. Isolated boulders of northern origin (mainly Eskdale granite), are found on the hills above Selattyn at about the same level.

The clays contain erratics of a Northern type, and are characterised by the presence of marine shells, mostly fragmentary.

Mr. A. C. Nicholson* of Oswestry has described the sands and gravels so well developed at Old Oswestry and Glopa,† and the

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* "On High Level Glacial Gravels at Gloppa," *Quart. Journ. Geol. Soc.*, 1892, vol. xlviii, p. 86.

† The word is spelt "Glopa" in the Ordnance Map. Nicholson renders it "Gloppa."

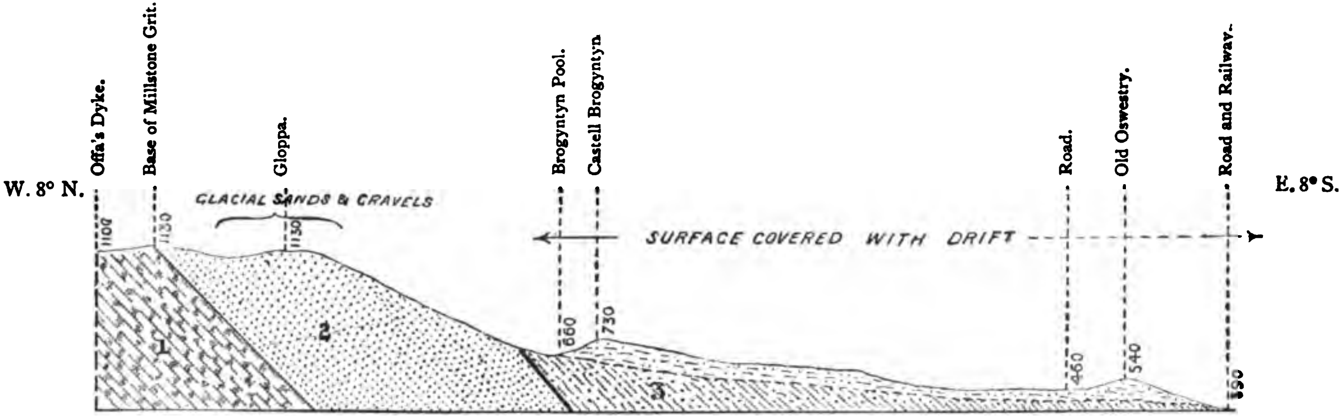

FIG. 36.—SECTION FROM GLOPPA TO OLD OSWESTRY.—*A. C. Nicholson.*

Horizontal scale: 2 inches = 1 mile. Vertical scale: 1 inch = 880 feet. The numbers above the section indicate heights above Ordnance datum.

1. Upper Carboniferous Limestone Beds. 2. Millstone Grit. 3. Lower Coal Measures.

(Reproduced by permission of the Council of the Geological Society.)

section he gives (Fig. 36) is reproduced by permission of the Council of the Geological Society.

The Glopa gravels occur at an altitude of 1,130 ft. They have been extensively worked to provide material for the filter beds of the Liverpool Corporation Waterworks, and good sections are exposed. No definite bedding can be made out in the series as a whole. They consist of coarse gravel with waterworn boulders, fine gravel, sand and boulder clay. The fine gravel and sands are sometimes false bedded, but the bands rarely persist more than a few feet. The Boulder Clay occurs in patches at all horizons and is frequently sheared round the larger erratics. Among the erratics there is a striking preponderance of boulders of Eskdale granite. Other Lake District rocks, such as the Buttermere granophyre and Andesitic agglomerate of the Borrowdale type, are also common. From South Scotland we get granites from Dalbeattie and Criffel. Carboniferous Limestone, Ganister, Coal, Cherts, Triassic Sandstone, Bala Slates and Grits, and Welsh Felsites have evidently been derived from more local sources.

Marine shells occur mainly in the sands. They are by no means common nor are they well preserved. Nicholson* gives a list of about fifty species of fossils which he collected after long and patient searching of the beds when they were more vigorously worked than at present.

The fauna bears a striking resemblance to that contained in similar beds on Moel Tryfaen, and the majority of the species have been recorded from the drifts of Lancashire and Cheshire. "A notable find was a portion of a tusk of *Elephas* which was discovered in the contorted strata in the upper part of the deposit."

He also lists *remanie* fossils from Silurian, Carboniferous Lias, and Gault and Chalk formations.

The Silurian and Carboniferous fossils can easily be accounted for as the ice must have overridden strata of these ages in order to reach the position in which they are found. Boulders of flints and hard chalk resembling Antrim types may have come from Ireland. I can confirm the occurrence of Lias fossils as, on a recent visit, I found *Ammonites communis* and *Gryphea incurva.* These have probably been derived from outliers of this age which are now hidden under the Boulder Clays to the north. (See p. 486).

At Old Oswestry precisely similar shelly sands and gravels are found at an elevation of 540 ft.

It is not worth while discussing the theories which have been advanced to account for the high level shelly sands and gravels. It is generally recognised by geologists that they were ice-borne and that the country stood at about the same level as at the present day. The shells are true boulders (some of them show glacial striæ), and the same agent which could uplift Triassic Sandstones from the low grounds could also bring shells from the bed of the Irish Sea into their present position.

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* *Op. cit.*, p. 91.

IGNEOUS ROCKS.

It now remains to consider the igneous rocks which occur in the Berwyns. They may be roughly divided into three series. The first is found in the central anticlinal area ; the second forms a peripheral series which extends in an almost unbroken sequence round the margins of the dome; the third is developed as a number of sills and dykes in the northern and north-westerly regions.

1. Central Series.

These rocks occur in force near Llangynog and in a strip of country to the north-east of that town. On the Survey map they terminate at a fault which runs along the Iwrch Valley. At Cwm Llechog, however, two bands occur 300 and 400 yards above the junction of the Iwrch and Cwm Llechog streams and at least a quarter of a mile to the north of the fault as mapped. There appear to be five bands, but the complex nature of the ground makes it impossible to say with our present knowledge whether they may not be repeated by faulting.

Near Llangynog the rock consists of a light grey felsite which shows spherulites as white spots on weathering. Under the microscope it exhibits an abundance of idiomorphic crystals of orthoclase in a felsitic matrix. Perfectly formed felspars often occupy the nuclei of the spherulites. A greenish mineral also occurs which may be a decomposition product of a ferro-magnesian mineral.

South of Llangynog a great boss of the felsite stands out like a pillar above the surrounding slates. It consists of columns which vary from one to two feet in diameter. On the east side the columns are nearly horizontal, their longer axes dipping 6° in a direction 35° N. of E. On the same side but at a lower level they dip 10° in the same direction. On the north face of the boss their axes dip 11°, 25° N. of E., and near the base 60°, 5° N. of E. On the west side they slope 30°, 75° N. of E. near the top, and 25°, 65° N. of E. below.*

On plotting these directions they appear to converge towards the north-west to a point outside the present extension of the boss. The part which remains may be a quadrant of a larger mass with columns radiating from the centre. It is quite possible that we are dealing with the plug of a volcanic neck which acted as a feeder to the sheets which penetrate the slates in the hills to the north-east.

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* These bearings are magnetic.

On the south side a fault containing a mineral vein separates the boss from the slates, so the actual contact is not visible. Across the valley at Craig Rhiwarth two bands of felsite of exactly similar composition penetrate the slates. Quarrying is carried on in the beds immediately below the igneous rocks, the slates in this position having a more perfect cleavage than those more distant.

Good exposures of the same rock occur at Pistyll Rhaiadr. Here there are two bands with slates intervening which merge into one bed to the south. They dip towards the western syncline about 10°. The lower bed is columnar and about forty feet thick. The upper part is vesicular, the individual vesicles being drawn out to two inches in length. Above this lies a silky slate twenty feet in thickness. Next follows a breccia with slate, grit, and felsitic fragments. The slate is sheared round "eyes" of grit and felsite, and one piece of included slate is eight feet long and fifteen inches wide. The upper felsitic sheet succeeds, and still higher normal slate is met with which continues for nearly a mile until it dips under an intrusive sill of the 3rd Series. The upper and lower margins of the slate in contact with the sill are converted into spotted slate. Other bands belonging to the Central Series are exposed on Doldrum, Godor, and Y-Garn. Nowhere in this series do we find rocks bearing any resemblance to volcanic tuffs. They are sometimes fragmentary but only where there has been shearing.

2. PERIPHERAL SERIES.

From the Carboniferous Limestone escarpment near Selattyn a series of three parallel bands of igneous rocks can be traced westwards to Llandrillo. One of these, the highest in the stratigraphical sequence, has not been observed beyond this point. The other two continue southwards with the strike of the rocks. The middle one persists as far as the south-west corner near Llanwddyn, where it bends back sharply into the interior with the over-folded slates. The overfold conceals the outcrop for some miles, but following the general strike of the strata we pick up the same band along the crest of Mynydd-y-Briw, and the circle is completed by connecting up with the masses of Glascoed, Mynydd-y-Bryn, Moelydd, and Blodwell Hall, which dip under the limestone escarpment.

The section (p. 480) shows that the latter may once have been continuous with the Selattyn rocks over the Bala anticline. The innermost band follows a course parallel with the middle one nearly as far as Llangynog. To the north of Hirnant it reaches the surface again and forms five distinct bands. These are probably only repetitions of the same bed caused by folding and faulting. The peripheral series can be conveniently studied, and in their normal development, at Llansantfraid-Glyn-Ceiriog, at Llandrillo, and about Craig Wen. At all these places there are good natural exposures and about Glyn they have been extensively quarried.

For purposes of reference we adopt the nomenclature introduced by Messrs. Groom and Lake. These authors refer to the outermost bed as the "Pen-y-Graig Ash," the middle one as the "Craig-y-Pandy Ash," and the lowest in stratigraphical order as the "Cwm Clwyd Ash." In the Survey Memoir they are called respectively the "Little Ash," the "Upper Bala Ash Bed" and the "Lower Ash Bed."

2 (*a*). PEN-Y-GRAIG IGNEOUS BAND.

Near Glyn this bed has been quarried in underground workings under Pen-y-Graig. Here it is fifteen to thirty-five feet thick, but rapidly thins out when followed towards the west. The general dip is 26° N.N.E. It can be traced for eight or ten miles to beyond Llandrillo. The lower part is a soft, compact, fine-grained bluish stone, which forms irregular columns and breaks with a conchoidal fracture. At the top of the bed it is vesicular and contains numerous amygdules filled with calcite. Some of these are more than two inches in diameter. The rock is traversed by calcite and quartz veins, and in the joints dendrites and pockets of manganese dioxide occur.

The slates above and the grits and slates below show little, if any, metamorphism. Under the microscope the stony groundmass is seen to contain large numbers of felspar laths, arranged in stellate groups or oriented in a manner suggestive of flow. They show signs of rapid growth and are frequently filled with secondary calcite.

A dark brown mineral moulds itself on the felspars and this may result from the decomposition of Hornblende.

2 (*b*). CRAIG-Y-PANDY IGNEOUS BAND.

The second bed has been worked in a large quarry on the right bank of the Ceiriog opposite Coed-y-Glyn, at Cae Deicws, and on the face of the Craig-y-Pandy.

It is the thickest and most persistent of the peripheral beds, and from the summit of Craig-y-Pandy it can be followed as a feature for many miles to the west.

In the river-side quarry it is seen in contact with the overlying Bala Slates (Bryn beds of Messrs. Groom and Lake). The line of junction has evidently formed a plane of movement, for the marginal portions are sheared and contain many fragments of slate, china stone, and limestone.

The middle portion is a white saccharine rock with angular enclosures of brown calcite. In thin slices it is seen to contain idiomorphic quartz in large quantities and fresh orthoclase felspar in a quartz mosaic. In parts it is vesicular, the amygdules being principally composed of chalcedony. The rock has been quarried at Cae Deicws, and Craig-y-Pandy for china stone. The photograph by Mr. G. Bingley, Plate XXVII, gives a view of a china stone quarry at the first of these localities.

Movement has also taken place at the lower margin of the sheet. For 33 yards below the china stone the rock is a mixture of slate, china stone, and blue igneous material, drawn out into lenticles parallel to the planes of shearing. The whole mass is traversed by numerous quartz veins, which have a general trend at right angles to the shear planes.

The same bed, as developed near the Milltir Gerig Pass, is described by Jukes as follows ("Geol. N. Wales" p. 216): "Crossing Craig Wen, and clearly visible on the roadside of the Milltir-Gerig, is the band of rock answering to the Upper Bala Ash bed. This, however, puts on here rather the character of a compact trap than an ash. It is a pale, greenish-grey felstone, but acquires a much more brecciated and ashy character towards the south, while northwards it becomes, perhaps, still more compact and trappean, and increases in thickness."

At Mynydd-y-Briw it occurs as two bands with slates between. Towards the east these become fused into one sheet which dips with the slates at a high angle. In some parts it is almost vertical. One of the bands contains a line of slate fragments about a foot from the top.

2 (*c*). CWM CLWYD IGNEOUS BAND.

The third band (Lower Ash Bed of Survey) appears about a mile to the south of the second band at Cwm Clwyd. It is quite accessible though not quarried in the Glyn district. On the moors towards the east it can be examined in many places, as at Craig and Cefn coch, where it stands out above the surrounding slates like a dyke. It is rudely columnar and is crossed by strong transverse joints, which give it a platy appearance. Like the foregoing it thickens in the Llandrillo area, and "near the grouse box on Craig Wen it is interstratified with apparently contemporaneous beds of dark greenstone."* Where the greenstone is in contact with the slates they are metamorphosed into spotted slate.

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* Jukes, *op. cit.*, p. 216.

It has already been mentioned that the peripheral bands are probably connected over the anticlinal area of Bala beds with rocks of a similar composition occuring near the Carboniferous Limestone in the south-east.

The most northerly patch at Glascoed is a hornblende andesite and in a quarry near the roadside it appears as great columns forty feet long, disposed with their longer axes horizontal. A larger mass to the south several square miles in area, forms the hill of Mynydd-y-Bryn.

At Moel-ydd the same rock is repeated by faulting. The southern boundaries of all three masses are cut off by faults which do not penetrate the limestone above. Other post-Carboniferous faults, with an east and west trend, have displaced the southern patches towards the east. The Blodwell Hall rock, though isolated from the others, may form part of the same series, but its exact relation is not clear.

There can be no doubt that the peripheral igneous series extends under the Carboniferous rocks, and it is probable that their source of origin lies in that area, perhaps not far from Glascoed.

3. BASIC INTRUSIVE SERIES.

The third series consists of a more basic type of rock. At Hendre Quarry, about two and a-half miles south of Glyn Ceiriog, it occurs as an intrusive sill, which can be followed east and west for several miles in a direction parallel to the peripheral series. On Cader Berwyn two sills are seen; one runs along the south face of the mountain and is continued through the slates forming the cirque above Llyn Llyn Caws. Another runs parallel to the first, and forms the summits of Cader Berwyn and Moel Sych. Farther to the north, at Carnedd-y-Ci, a band of similar rock lies at the base of a rock which may be correlated with the Cwm Clwyd Ash. It is probable that this is only a repetition of the same Ash as developed at Clochnant, near Llandrillo, which likewise has a basic injection at its base.

While the rest of the igneous rocks of the Berwyns have never been adequately described, parts of the basic series have been the subjects of papers by Mr. C. C. Moore, F.I.C.,* and Mr. H. Stanley Jevons,† M.A., F.G.S.

Moore confines himself almost exclusively to the rock as exposed at Hendre. He deals in an exhaustive manner with the chemical composition and physical characters of the intrusion and the adjacent slates.

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* "Presidential Address, Liverpool Geological Society," 1903

† *Geol. Mag.* Dec. v, Vol. xi, No. 1, Jan. 1904.

The following table gives the results of the analysis of specimens, taken at measured distances, both from the slates and the intrusion.

ANALYSIS OF ROCKS FROM HENDRE QUARRY, PEN-Y-BONT, GLYN-CEIRIOG, N. WALES.

No. 1.—Unaltered Slate, 92 ft. above upper junction of intrusion.
No. 2.—Altered Slate, 1 ft. above intrusion.
No. 3.—Altered Slate, 2 in. above intrusion.
No. 4.—Dolerite, 2 in. below upper junction.
No. 5.—Dolerite, 1 ft. from junction.
No. 6.—Dolerite, middle of intrusion.
No. 7.—Dolerite, 2 ft. above bottom of intrusion.
No. 8.—Altered Slate, 2 ft. under bottom of intrusion.
No. 9.—Unaltered Slate, from below intrusion.

	1	2	3	4	5	6	7	8	9
S. Grav...	2·78	2·82	2·82	2·81	2·82	2·91	2·85	2·81	2·78
% Poros...	4·70	1·15	1·12	0·12	0·23	0·64	0·54	0·61	4·74
SiO_2 ...	60·68	60·28	58·72	45·34	46·12	47·88	45·73	56·86	60·42
TiO_2 ...	1·39	1·40	1·35	0·14	0·16	0·18	0·18	1·29	1·40
FeO ...	5·05	5·12	5·62	8·29	8·49	6·53	8·86	5·85	5·10
Fe_2O_3 ...	6·07	6·15	6·60	4·67	4·66	3·73	4·81	5·72	6·09
Fe_2S_3 ...	0·46	0·48	0·54	0·54	0·60	0·69	0·62	0·52	0·48
Al_2O_3 ...	16·82	16·86	17·15	14·03	13·43	13·64	14·22	16·73	16·80
CaO ...	0·56	0·54	0·52	10·18	9·95	12·42	10·16	1·23	0·54
MgO ...	1·37	1·41	1·95	7·51	7·06	8·64	8·23	2·67	1·40
Na_2O ...	1·60	1·62	1·54	2·12	2·27	2·15	2·26	1·36	1·58
K_2O ...	2·12	2·15	1·97	0·48	0·46	0·44	0·45	3·23	2·18
CO_2 ...	0·22	0·22	0·23	4·08	4·11	1·07	1·01	0·23	0·22
H_2O ...	3·66	3·77	3·81	2·62	2·69	2·63	3·47	4·31	3·79
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
% of Fe Ferrous	48·0	48·1	48·6	66·3	66·9	66·0	67·2	53·1	48·1
$CaCO_3$	0·50	0.50	0·52	9·27	9·34	2·43	2·29	0·52	0·50
O. Ra. 1	0·376	0·381	0·408	0·695	0·645	0·652	0·696	0·430	0·378
O. Ra. 2	0·374	0·379	0·406	0·611	0·579	0·633	0·676	0·428	0·377

The water is all chemically combined. The carbonic acid is calculated to carbonate of lime only for comparison.

Oxygen Ratio 1 is calculated on the silica and titanic acid and all the bases. Oxygen Ratio 2 is calculated on the silica and titanic and carbonic acids and all the bases.

All the analyses have been calculated to add up to 100 in order to be comparable with one another.

Percentage of iron as ferrous refers to the percentage of total iron existing in the ferrous condition.

It is demonstrated that towards the interior the mass shows a very marked increase of gravity, and at the same time it also shows an increase of porosity. These changes indicate that the centre of the intrusion has suffered a shrinkage of 3 per cent. and afford a striking example of the importance of crystallisation as a factor in producing volume alteration in igneous rocks. It explains why highly crystalline rocks possess such appreciable amounts of porosity, and the production of spaces in the interior of rock masses which cannot be traced to any outside agency. The slates above and below the igneous rock have been altered to a distance of ninety-two feet from each margin. Chemically they have undergone very little change, even when taken very close to a junction. Physically they have suffered a reduction in volume, well shown by their specific gravities and porosities. Moore estimates that there has been a shrinkage of about six feet in the 184 ft., which show signs of metamorphism.

Spotted slates occur at both margins. Wherever this series comes in contact with the slates the same features are observed and in Carnedd-y-Ci the change has been sufficient to produce crystals of chiastolite.

Jevons considers the rocks about Carnedd-y-Ci to be keratophyres as they consist essentially of albite and diopside. He suggests that a large number of centres of eruptions existed at the time of their intrusion, and one he places at Blaen Llynor, near Llandrillo.

Near Milltir Gerig an olivine dolerite occurs in Nant Llwyn Gwern which does not seem to correspond with any of the igneous rocks in the above-mentioned series.

GENERAL REMARKS.

It is always easy to speculate when one's knowledge is incomplete, and in discussing the possible origins and ages of the various igneous beds it is to be understood that I do not present them as ripe opinions, but rather as points to be observed and considered by the members of the Association when they visit the district.

The peripheral series and the central series are fragmental in parts. Does this necessarily mean that they are contemporaneous ashes thrown out from vents and spread over the land or the floor of the sea? One naturally inclines to this view at first sight, since the different bands appear to follow the same stratigraphical horizon. Taking the Bala Limestone as a datum line the parallelism is certainly very striking. But the third series, which are undoubtedly intrusive, show a parallelism just as close.

Their fragmental condition also favours the opinion that they are true ashes, but here again we must keep in mind that fragmental rocks may occur in intrusives. Although Jukes mapped the peripheral series as volcanic ashes he seems to have had misgivings on the point when he says "It is very difficult, if not impossible, to distinguish between a decomposed trap and an ash,"* and I have quoted above observations from the same author that in the case of the "Upper Bala Ash Bed" it puts on rather the character of a compact trap than an ash in certain places. Moreover, we have seen that the rocks have been subject to shearing, and Messrs. Groom and Lake have shown in one district that earth stresses have affected the rocks to an extent little suspected.

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* "Geology of N. Wales," p. 216.

The igneous rocks would naturally serve as resistant bands to such movements as took place subsequent to their solidification, and the planes of shearing would tend to run with them rather than against them.

With true ashes we should naturally expect that they would exhibit signs of bedding, alternations of fine and coarse material and volcanic bombs. So far as I have observed I have never seen any sifting of the material into finer and coarser bands, and cases where bedding was suspected have always turned out, on careful examination. to be orientation due to shearing.

However, Dr. Groom, in the discussion which followed his paper, cited above, states that he has seen true bedding and even false bedding in the Pandy ashes.

With the exception of one bed, the Cwm Clwyd ash, the peripheral series contain no fragments which could not have been derived from the neighbouring rocks and the beds themselves. Pieces of a red rock resembling felsite occur in this bed between Cwm Clwyd and Springs which, so far as I know, are not found massive in the Berwyns. Thus we see that while some features which the igneous rocks display are suggestive of an intrusive origin there are others which militate against this view.

Any theory put forward to account for these rocks must deal with the series as a whole, and not be applicable only to one limited part. We have noted that the igneous rocks do not invade the synclinal areas filled with beds of Wenlock age. Does it necessarily follow that they are of pre-Wenlock date?

It is well-known that there is a definite connection between the depression of an area and igneous intrusions. During folding there must be a relative, compensating upward movement on either side of the depressions, and a lateral flow of deep-seated, yielding masses towards the anticlines.

In the Berwyns all the igneous rocks run in lines parallel to synclines, and rise with the strata towards anticlines. If they were extrusive either as lava flows or as tuffs, we must grant a succession of eruptions beginning in Llandeilo times and persisting until the close of the Bala period.

The very slight amount of thermo-metamorphism which the sedimentary rocks show when in contact with the igneous, at least indicates that the central and peripheral series did not remain at a high temperature for a lengthened period. But a single injection of comparatively thin beds does not materially alter the surrounding strata, and even volcanic necks are known where the change is infinitesimal.

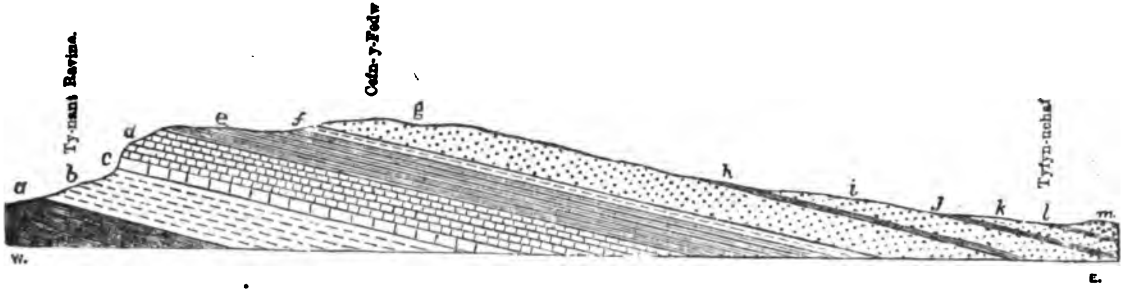

FIG. 37.—CEFN-Y-FEDW SECTION.—*G. H. Morton.*

m. Aqueduct Grit, or Upper Sandstone.
l. Upper Shale.
k. Dee Bridge Sandstone.
j. Lower Shale and Limestone.
i. Middle Sandstone.
h. Cherty Shale.
g. Lower Sandstone.
f. Sandy Limestone.
e. Upper Grey Limestone.
d. Upper White Limestone.
c. Lower White Limestone.
b. Lower Brown Limestone.
a. Old Red Sandstone.

Further, a molten rock coming in contact with the cool margins of sedimentary strata would be rapidly chilled at the edges. The succeeding flow would tend to break off this solidified material as well as the rocks above and below, and these would become incorporated in the general mass. Flow structure, shown by lath-shaped felspars moulding themselves round inclusions, occurs in all the so-called ashes, and this character as well as their vesicular margins is quite compatible with rapid injection.

It has been pointed out that the distribution of the igneous bands is closely associated with the folding of the dome, and if we grant that these have any genetic connection some of our difficulties seem to be met. In the bulging of the dome there must have been left spaces into which deep-seated material could be injected as laccolitic intrusions. On this theory we only need one period of activity which harmonises with a time of known earth folding.

In the meantime we must wait until the igneous rocks have been subjected to careful petrographical examination and the sedimentaries have been more extensively mapped before we can hope to provide a final answer.

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ORDINARY MEETING.

June 12th, 1908.

Prof. W. W. Watts, F.R.S. (President), in the Chair.

The following were elected members of the Association: Charles Binns, Miss L. B. Morris, Miss Alice Elizabeth Richards.

On this occasion the new Geological Department of University College was thrown open to the inspection of the members, and Prof. E. J. Garwood gave a lecture on the origin of certain mountain-tarns of the St. Gothard and elsewhere.

ORDINARY MEETING.

July 3rd, 1908.

Prof. W. W. Watts, F.R.S. (President), in the Chair.

The following were elected members of the Association: William T. Burgess, F.C.S., F.I.C., J. C. M. Given, M.D., M.R.C.P., William Head, Thomas D. Nicholson, M.D., L. Richardson, F.R.S.E., F.L.S., F.G.S., Frederick Sadler, Thomas Franklin Sibly, D.Sc, F.G.S., Rev. E. C. Spicer, M.A., F.G.S., W. C. R. Watson.

A paper, descriptive of the district to be visited during the Long Excursion, was then read: "The Geology of the Berwyn Hills," by Joseph Lomas, F.G.S. The paper was illustrated by diagrams and lantern slides. It is printed pp. 477-500.

EXCURSION TO POTTERS BAR.

SATURDAY, APRIL 11TH, 1908.

Director: WILLIAM WHITAKER, B.A., F.R.S., F.G.S.

Excursion Secretary: MISS JOHNSTON.

(*Report by* THE DIRECTOR.)

HAVING left King's Cross by the 1.15 p.m. train to Potters Bar the party, reinforced by members of the Hertfordshire Natural History Society, numbered 31.

From the station the members walked along Mutton Lane across the Tertiary beds to the outcrop of the Chalk by Mimms Hall.

At the brook the geology of the district was described, and the course of the stream was noticed. This stream is the result of the drainage of the impervious London Clay to the south, and becomes a dry channel when there has been no rain for some time.

The water that flows over the clay-tract southward of Mimms Hall sinks into swallow-holes on reaching the Chalk; but after wet weather the flow gradually increases, the stream persists beyond the higher swallow-holes, and at last, after heavy rainfall, the flow becomes continuous at the surface all along.

The most marked swallow-holes in the higher part of the stream are at a sharp bend about a third of a mile north of Mimms Hall. This set was examined, and the water was seen to be sinking down in several places.

A little to the north, at the next sharp bend, the water was pouring down into a small hole, and this was indeed the only case seen of a swallow-hole in clear and thorough working order.

Here a sample of the water was taken at the mouth of the hole by one of the party, Mr. W. T. Burgess, for analysis, and he has kindly sent the following report on it:

Total solid residue	36 64	Parts per 100,000.
Ammonia, free and saline	·072	
,, albuminoid	·032	
Oxygen consumed, 4 hrs. at 80° F	·56	
Nitrogen as Nitrates	·125	
,, ,, Nitrites	traces	
Combined chlorine	2 9	
Total hardness	21 5	

The water was turbid and brown. It was very impure compared with the supply obtainable from deep chalk-wells. Most chalk-supplies give, in the 2-ft. tube, merely the faint blue colour of pure water. Some, however, which are faintly but distinctly yellow, show probably rapid infiltration of surface-water through some form of swallow-hole.

In the colour-meter, devised by Mr. Burgess, this sample, after the suspended matter had subsided, had a colour equal to that of a depth of 100 millimetres of the standard colour-solution.

There are some very small sink-holes by the stream just northward, and evidence of a late flood that had spread over the flat bottom of the valley was given by the mud that occurred away from where water then was, and the finding in one of these mud-deposits of a fish, all but dead, but which recovered on being put into the stream.

Hence to Warren Gate, the western bank of the stream-channel (which contained little water) showed interesting sections of peaty and clayey earth in the gravel.

Below this the channel was mostly dry, and so the fine set of swallow-holes at Water End could be examined, the party going down into many holes, the sides of which were more or less coated with mud, and which but a short time before had been under water, as was shown by twigs, straw, etc., left in the bushes above them. Some of the party had seen this flood, and described it to the others.

This particular tract seems to have been altogether appropriated for the exhibition of swallow-holes, of which there are many along the fairly deep and winding channel. The only fluid, however, that could be seen running into any of them was of the nature of sewage, and this method of getting rid of it did not commend itself to the beholders.

Other swallow-holes were seen close by, up the tributary valley at the western edge of Potterells Park, along which the party walked to reach the traps at Welham Green, whence they drove into Hatfield, where the afternoon's proceedings finished with tea at the Salisbury Hotel and a vote of thanks to the Director. Return was made to London by the 6.53 train.

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EXCURSION TO BOXMOOR.

SATURDAY, APRIL 25TH, 1908.

Director: WILLIAM WHITAKER, B.A., F.R.S., F.G.S.

Excursion Secretary: A. H. WILLIAMS.

(*Report by* THE DIRECTOR.)

SIR JOHN EVANS had intended to act as one of the Directors of this Excursion, but he was not well enough to be present, and it is with the greatest regret that we record his death on May 31st.

A party of twenty assembled at Boxmoor Station early in the afternoon. They included a contingent of the members of the Hertfordshire Natural History Society.

The heavy snowfall which had occurred on the day of the Excursion, and also on the previous day, somewhat interfered with the proceedings, though it added to the beauty of the walk, except in the brickfields which were the special object of the Excursion. Footpaths had to be avoided, at least until late in the day, and the party went along the road to Bennett's End.

Here the Acorn Brickfield, west of the hamlet, was visited, and a curious section was seen at one part of the pit, a little south-east of the buildings. The loamy basement-bed of the London Clay, with two layers of pebbles, but without shells, was seen in vertical junction with the clay of the Reading Beds, grey just at first and then mottled. This sign of marked disturbance was found to be intensified by the occurrence of Chalk but a few feet off, pointing to the probability of a fault, as the Chalk ought not to come within about 30 feet of the London Clay.

A hope was expressed that the Hertfordshire Natural History Society would keep an eye (and a camera) on this very peculiar section. It will be remembered that a fault was seen and figured many years ago in a neighbouring but now abandoned pit. The greater part of the pit is in the superficial brick-earth, which here covers both Chalk and Tertiary beds.

A fine section of this brick-earth was seen in another pit on the western side of the footpath westward of the brickyard, which shows brown and red bedded loam, somewhat curved and of considerable thickness.

The walk was continued to the Greenfield brickyard at Leverstock Green, where many large blocks of puddingstone have been found in the brickearth, as well as long and large flints, some of which had been placed upright in part of the pit, in which again Chalk was reached in places, sometimes with a trace of the Reading Beds (sand).

Finally the Highfield brickyard, northward of Wood Lane End, was visited, where masses of pebbles occur in the loam. This pit is notable for the finding of flint implements, as described by Sir John Evans (*Quart. Journ. Geol. Soc.*, vol. lxiv., pp. 3-5), whose adoption of Mr. Worthington Smith's view that the brick-earth is a deposit of lacustrine origin was here alluded to.

A trudge of about two miles through the snow brought the party back to Boxmoor, where a well-earned tea was enjoyed at the Railway Hotel, and after a vote of thanks to the Director, proposed by Mr. J. Parkinson, the return to London was made by the 7.35 train.

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EXCURSION TO CHARLTON AND ERITH.

SATURDAY, MAY 2ND, 1908.

Director: A. L. LEACH.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR)

THE party, in number about thirty, arrived at Charlton at 2.25 p.m., and walked to Gilbert's Pit in Hanging Wood, where in a fine section of the Lower London Tertiaries the structure of these beds is shown very clearly. The Director briefly indicated the chief features of interest in the pit, which affords one of the best general Tertiary sections in the whole London District. From the "bull-head" at the base of the Thanet Sand to the Blackheath pebble-beds, the series is fully represented.

The Thanet Sand, for which the pit is now worked, yields a few internal sand-casts of two species of *Pholadomya*, and specimens recently obtained were exhibited on this occasion. The specimens were perfect but very fragile, and every trace of shelly material had disappeared.

At the junction of the Thanet Sand and the Woolwich Beds a thin pebble-bed was seen, and the method of working the pit makes the division quite clear. As only the Thanet Sand is of economic value, the overlying beds are stripped off, and a level working platform is formed on the top of the Thanet Sand. Two species of *Cyrena* (*C. cordata* and *C. cuneiformis*) were obtained in the Woolwich Clays, and small crystals of selenite were found in cavities in the hard mottled clays. The general sequence of the Woolwich Beds, viz., bottom-bed of green loam, shelly clays, thinly bedded clays and loams, was shown to be present here.

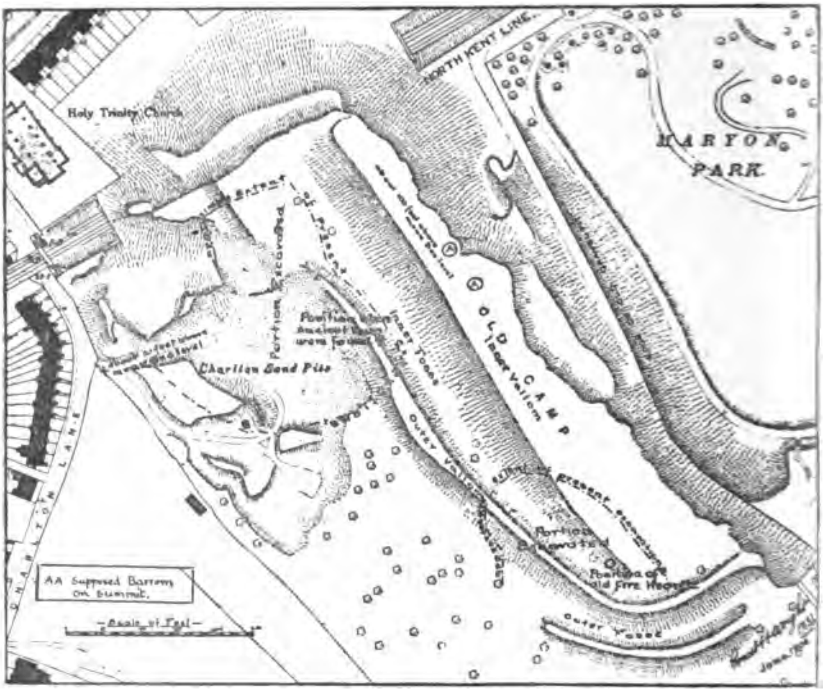

FIG. 38.—PLAN SHOWING THE CAMP IN HANGING WOOD, CHARLTON, AND THE PRESENT EXTENT OF THE SAND-PITS.

(Reproduced by permission of the Council of the Woolwich Antiquarian Society.)

An irregular junction was traced between the Woolwich and the Blackheath Beds, and reference was made to the variable position of the base of the Blackheath pebble-beds in relation to the Woolwich Beds. Here the base-line runs generally through the "thinly-bedded loams," but in one part of the pit the pebble-beds cut down through the "shelly clays" into the "bottom green loam," thus recalling the section opposite Hope Cottage, Plumstead, which was visited by the Association in 1906.

The party now walked to the top of the hill to examine some sections of Woolwich and Blackheath Beds exposed on the steep slope above Maryon Park. Here the *Cyrena* clays are well developed, and the variable character of the pebble-beds is exemplified, small pea-gravel passing laterally and vertically into beds of much coarser structure. Some interesting examples of "hill-side drift" or "run of the hill" were examined on the slope above the railway.

The remains of an ancient camp (see Fig. 38) were noted on the hill where the continued extension of the sand-pits is rapidly completing the destruction of what was once an important earthwork. Some evidence of its age is afforded by the vases (probably Roman) discovered in the inner trench in 1906, but the camp itself may be pre-Roman.

At 4.4 p.m. the party left Charlton, and arrived at Erith at 4.29 p.m. The great ballast-pit (Parish's) shows the same general arrangement of Lower London Tertiaries, but red mottled clays in the Woolwich Beds are more pronounced than at Charlton, and the section includes also the base of the London Clay. Here the full sequence of the Lower London Tertiaries can thus be examined in one general section. The Thanet Sand is almost unfossiliferous, but some fish vertebræ were obtained by Dr. A. E. Salter a few years ago. The Woolwich Clays also appear to be unfossiliferous, but this may be due to decalcification.

On ascending a clayey slope of "foundered" Woolwich Beds a patch of drift was seen resting in a hollow of Blackheath Beds; a few mammoth teeth have been obtained here. In the northern corner of the workings a remnant of the pebbly basement bed of the London Clay was seen overlain by a few feet of weathered brown clay, but the section was not so good as on the occasion of the visit (September 28th, 1907) of some of the delegates to the Centenary of the Geological Society, when the succession was quite clear.

In a new cutting in this part of the pit a pebble-bed, probably the Basement-bed of the London Clay, was seen dipping at a high angle and becoming involved with Blackheath Beds. The Director considered this to be due to landslips, and referred to the section* (seen by Mr. Whitaker many years ago) which showed Pleistocene drift underlying Eocenes.

After tea at the Prince of Wales Hotel, Erith, the Director was thanked for his services, and the party returned to London by the 7.4 p.m. train.

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* "Geology of London," *Mem. Geol. Surv.*, vol. i, p. 141.

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EXCURSION TO SAVERNAKE AND BEDWYN.

SATURDAY, MAY 16TH, 1908.

Directors: H. J. OSBORNE WHITE, F.G.S., AND LLEWELLYN TREACHER, F.G.S.

Excursion Secretary: GEORGE W. YOUNG.

(*Report by* H. J. OSBORNE WHITE.)

THE London party reached Savernake shortly after 11.0 a.m., and were joined at the station by a few of the Association's Wiltshire members and friends, who brought the number up to seventeen.

The Great Western Railway's station and goods-yard at Savernake are situated in a wide cutting, which shows, on its northern side, a long and clear section, about 20 ft. in depth, of light grey-green glauconitic sand, containing bands of rough calcareous concretions, and belonging to the highest part of the Selbornian Series.

When the cutting was being widened, in 1904, many fine siliceous sponges, of the species occurring in the well-known Warminster Greensand, were to be obtained, but since the sand has been cut back to an even face these and other fossils are less easily found. The few forms observed on the present occasion included: a large *Nautilus* (probably *N. expansus*), *Cidaris* sp., *Catopygus columbarius*, *Discoidea subuculus?*, *Pachypoterion* (fragments, probably *P. robustum* and *P. compactum*), and numerous examples of a branching object, like the "*Spongia paradoxica*" of the Lower Chalk of Hunstanton.

Leaving the station, the party walked northward up the Chalk escarpment to Durley, noticing on the way a shallow cutting in the Lower Chalk, on the Midland and South-Western Junction Railway, which here runs parallel to the Great Western line. Mr. W. H. Bell, who was present, suggested that the northern limb of the Pewsey anticline is broken at this spot by a strike-fault, running between the two railways.

Higher up the slope a good view over the Vale of Pewsey was obtained, the prospect taking in the Inkpen range, on the east and south-east, and Etchilhampton Hill, near Devizes, on the west. The form of the east-and-west ridge or swell of the Upper Greensand, where it arches over the anticline along the axis of the vale, could be clearly seen from this point. These and other features of the landscape having been noticed, there followed a rather lengthy and inconclusive discussion on the mode of formation of the dry valleys which furrow the dip-slopes of the Chalk on either side of Pewsey Vale.

In brief, Mr. G. W. Young contended that such combes were due chiefly to differential solution; that their channels had been roughly marked out on a cover of Clay-with-flints, or some other impermeable bed, and subsequently opened to their present depth and width by the corrosive action of the rain-water concentrated in them. This view was opposed by the Directors, Mr. Treacher pointing out that it was not in accord with the observed character and distribution of the drift in certain of these valleys, while Mr. White expressed his disbelief in the ability of solution so frequently to reproduce, in a limestone, a definite group of "destructional" phenomena closely resembling that to which the combined action of stream-erosion and soil-creep gave rise in other sorts of rock. The latter speaker was of opinion that the chalk combes in this part of the country were mainly of mechanical origin, and that there was good evidence of this in the details of their form.

Passing over the crest of the escarpment, the party walked across Tottenham Park to an almost overgrown chalk-pit about one-third of a mile north of Durley Gate. Here Mr. Treacher had previously obtained *Uintacrinus* and *Actinocamax verus*, and on the present occasion plates of the former fossil were found without difficulty.

Thence, a pleasant walk of about three miles, in a generally northward direction, brought the members to the gravel pit at Knowle Farm. This excavation, which is situated on the southern slope of the Froxfield Valley, and close to the main road from London to Bath, is being cut back into the rising ground, and the gravel exposed in the main working-face has lately begun to show signs of stratification.

In anticipation of the Association's visit the workmen had collected upwards of a score of flint implements, including rough, edge-chipped Eolithic forms, and others which looked like poor copies of Acheulian types. A few of the tools showed patches of the well-known glaze, and these, and some good examples of glazed unworked flints, were quickly bought up.

At the request of the Directors, Mr. S. B. Dixon, who discovered the implementiferous character of the Knowle gravel some years ago, kindly gave the party an account of the deposit, and of his views with regard to its formation. In the course of his address Mr. Dixon stated that the implement-bearing gravel was from 8 to 10 ft. thick, and rested upon a much disturbed (piped) surface of the Upper Chalk. The tools first discovered were lying together near the surface and in great numbers, between 2,000 and 3,000 having been obtained from a comparatively narrow space. They varied in size from 1 to 6 in., and were of many types—some lance-shaped, some ovoid, and with the better-worked implements there were rough drills and scrapers. With very rare exceptions, all the implements were of flint, but one or two of Greensand Chert had been found. These must have been brought from a distance, as the particular sort of chert of which they were made did not occur locally. They were much like the chert palæoliths found at Axbridge, in Devonshire.

The Knowle implements—continued Mr. Dixon—occurred both in a perfectly fresh and in a rolled and waterworn condition. In the lower parts of the deposit, now being worked, they were much less numerous than in the upper parts, and generally of ruder types. The deposit itself was situated at the junction of three valleys, and he believed it to have been formed by the streams which cut out these valleys during the warmer intervals of the Glacial Period. The abundance of palæoliths marked Knowle as the site of an early settlement, but although a good deal of the gravel had been carefully sifted, no mammalian bones or other remains of a contemporary fauna had yet been discovered.

At the conclusion of his remarks Mr. Dixon exhibited a number of local implements, some finely glazed. The Rev. H. G. O. Kendall, of Winterbourne Basset, also showed a small collection illustrating the extraordinary mixture of Palæolithic types which the Knowle tools display, and, thanks to Mr. J. Cross, the members of the party were able to compare these with some implements from Swanscombe, in Kent.

Quitting this interesting spot with reluctance, the party resumed their walk, south-eastwards, by Upper Horsehall Hill to Chisbury Lane, stopping on the way to glance at pits in the *M. cor-anguinum* and *Uintacrinus* Chalks and in a pebbly Valley Gravel.

In another small chalk-pit, half-a-mile south of Chisbury Lane Farm, a detachment of the party collected, in a few minutes, the following fossils:

Inoceramus cuvieri
Ostrea vesicularis
Spondylus dutempleanus
Proboscina radiolitorum
Bourgueticrinus

Echinocorys scutatus
Marsupites testudinarius
Porosphæra globularis
,, *nuciformis*
,, *pileolus*

The next objects of interest were the British camp of Chisbury, and some pits in the high-level flint-and-sarsen gravel which caps the summit of Chisbury Hill. In the upper part of the lane which follows an ancient earth-work (named "Wans Dike," on the Ordnance Map) down the south-eastern side of the hill some small exposures of interbedded red-brown sand and grey clay, of Lower Bagshot age, were noticed, and the disturbed junction of Reading Beds with the Chalk could just be made out lower down the slope. Lumps of the hardened chalk ("Bedwyn stone") which occurs at, or immediately below, the base of the Reading Beds in this neighbourhood, were seen in the banks of the lane, and fragments of *Marsupites*, *Echinocorys*, and other fossils were readily found in rubble associated with them.

Having admired the view over the Brails, and listened to a short history of the borough of Great Bedwyn, by Mr. Treacher, the party descended into the village for tea at the "Cross Keys." Here, on the proposal of Mr. G. W. Young, the Directors were thanked for their services, and the Excursion terminated at Bedwyn Station shortly after six o'clock.

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EXCURSION TO PENSHURST AND THE MEDWAY VALLEY.

SATURDAY, MAY 30TH, 1908.

Director: E. W. HANDCOCK, B.Sc., F.G.S.

Excursion Secretary: A. C. YOUNG.

(*Report by* THE DIRECTOR.)

THE London party reached Penshurst Station at 2.26, and were joined a couple of minutes later by the Director, with a further contingent who had foregathered at Tonbridge, bringing the number up to forty.

A move was at once made to an exposure of Tunbridge Wells Sand at Moorden Farm (quarter mile from the railway station). Here the Director pointed out that, as the Association had visited, during the excursion season of 1907, sections of Wadhurst Clay, Weald Clay, and Ashdown Sand, he had arranged the day's programme with the view of completing the sequence of the Wealden Beds, and proposed showing the party four typical sections of Tunbridge Wells Sand, two of which belonged to the Upper Beds immediately underlying the Weald Clay, and two to the lower portion.

The sections of Tunbridge Wells Sand to be visited would not be of great interest to fossil collectors, but they showed some interesting structures in the shape of "honey-comb" weathering, and peculiarly well-developed jointing. The hard rocky nature of the Upper Beds also formed a picturesque feature of the landscape, as would be seen later in the grounds of Redleaf, where the rock exposures resembled those on Tunbridge Wells Common.

Proceeding, by kind permission of Mrs. F. E. Hills, to the private grounds of Redleaf, the rocks before mentioned, with their characteristic features, were examined, and, under the courteous guidance of Mr. G. Ringham, the head gardener, portions of the gardens, including many excellent specimens of ornamental trees, and exquisite masses of azaleas in full bloom, were inspected. On leaving Redleaf, the President, on behalf of the party, heartily thanked Mr. Ringham for the enjoyment the latter had afforded them.

The Director now led the way to an elevated spot in Penshurst Park, where another section of Tunbridge Wells Sand was found, and a view obtained of the park and Penshurst Place and Church, about half-a-mile distant.

Mr. Handcock, deviating from Geological matters for the moment, gave a few details of the history of Penshurst, associated as it is with the names of Philip and Algernon Sidney and

William Penn, and whose praises have been sung by Spenser, Ben Jonson, and Waller.

With regard to the occurrence of Grinstead Clay in this area, the Director ventured the suggestion that the exposure noticed by Drew and mentioned by Topley in his Memoir on the Weald was really an outlier of the Weald Clay. Such an outlier occurs, and is mapped, in the grounds of Redleaf, and this probably extends farther east than is shown on the map. A digging for a water main in the summer of 1907 was made through this clay, and specimens of clay obtained by the Director match, in every particular (especially in colouring), another set of specimens obtained near Tunbridge Wells, where a trench 14 ft. deep was dug through an outlier of undoubted Weald Clay.

A significant fact mentioned by Drew is that this clay overlies white sand rock, which is always the character of the Upper Tunbridge Wells Sand in this area.

Passing through the northern boundary of Penshurst Park another section of Tunbridge Wells Sand (lower beds) was seen at Paul's Hill, near Leigh, after which the party descended to the River Medway at Ensfield Bridge, close to the site of the Penshurst coal-boring. Some of the cores, of varying diameter, were exhibited, the deepest (and smallest) consisting of Kimeridge Clay which was reached at a depth of about 1,500 ft. After passing through about 350 ft. of that formation the boring was abandoned.

A gravel section about 100 yards from the bridge was next examined, and about a mile farther down the valley another section of gravel resting on Wadhurst Clay proved of interest.

Specimens of all these gravels, as well as the Starve Crow gravel (visited by the Association in April, 1907) and the Hever Lodge gravels of the River Eden, were placed in view by the Director at Sir Andrew Judd's Commercial School, whither the party adjourned for tea.

After tea the President, speaking on behalf of the Association, thanked the Director for his services, and the Headmaster of the School for placing the rooms at their disposal.

The London members left Tonbridge by the 7.25 train.

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EXCURSION TO THE MID AND SOUTH COTTESWOLDS AND TO THE TORTWORTH AREA.

JUNE 5TH TO 9TH (WHITSUNTIDE), 1908.

Directors: L. RICHARDSON, F.R.S.E., F.L.S., F.G.S., and PROF. S. H. REYNOLDS, M.A., F.G.S.

Excursion Secretary: DR. C. G. CULLIS.

(*Report by* THE DIRECTORS.)

PART I. BY L. RICHARDSON.

THE official party left Paddington on June 5th at 6.10 p.m., and arrived at Stroud at 8.28 p.m., the headquarters being at the Imperial Hotel, Stroud.

On Saturday, June 6th, the members left Stroud by the 8.48 a.m. train, arriving in Cheltenham at 9.56 a.m., where they were met by Mr. Richardson. From the station they drove to the Battledown Brick Works (Messrs. Webb Bros.').

Entering by the Hales Road gate the "sand-pit" was first studied. It shows about 16 ft. of yellow quartzose sand resting upon blue clays of *Valdani* hemera. The sand forms part of the bed upon which the greater portion of Cheltenham is built, and which attains a thickness of anything up to 50 ft. Hillwards it passes into the gravel of Inferior Oolite and Upper Lias limestones, and valewards—in the direction of the Severn—into the so-called Northern Drift.

Passing through the works and under Hayward's Road, the large pit was entered. Its size and depth elicited comment, and not without reason, for its maximum length is about 220 yards, its greatest breadth 75, and its depth, in the deepest place, 70 ft. The deposits have a south-easterly inclination, and are principally clays of *Valdani* and *striati* hemeræ. The upper part of the *Striatum*-Beds contains many nodules of yellowish limestone and ferruginous concretions, the latter consisting of numerous concentric layers grouped around a mud pellet or fossil for a nucleus. The deposit in which these nodules occur was called the "Yellow Lias" by the earlier geologists, and has yielded, and still does provide, a rich and well preserved assemblage of fossils.

Above the *Striatum*-Beds, at the extreme eastern end of the pit, is seen the very base of the *Capricornus*-Beds, somewhat sandy beds with *Plicatula spinosa.* In the hillside above the pit the impure limestones of the *Capricornus*-Beds, which were exposed when the Battledown reservoir was made, must crop out; while the increasingly sandy condition of the succeeding deposits, those of *algoviani* hemera (or the Lower *Margaritatus*-Beds of Quenstedt) is evidenced by the growth of gorse bushes.

Battledown Hill is capped with the Marlstone, but it is now nowhere exposed.

From Webbs' pit the drive was continued to the foot of Leckhampton Hill. Before commencing the climb, Pilley or Pilford Pit was pointed out. It is now closed down, but the *Capricornus*-Beds were formerly well exposed there and richly fossiliferous. The very base of these beds was pointed out at Webbs' pit, so that Pilford continues the upward sequence.* The sandy beds of *algoviani* hemera are not exposed anywhere on the slopes of Leckhampton Hill; the best places to see them are at Robin's Wood Hill and Stonehouse, at both of which places the *Capricornus*-Beds are seen below. Neither is the Marlstone exposed at Leckhampton Hill, but the platform to which it gives rise is noticeable, and forms the site for Hill House (see Plate XXVIII, Fig. 1).

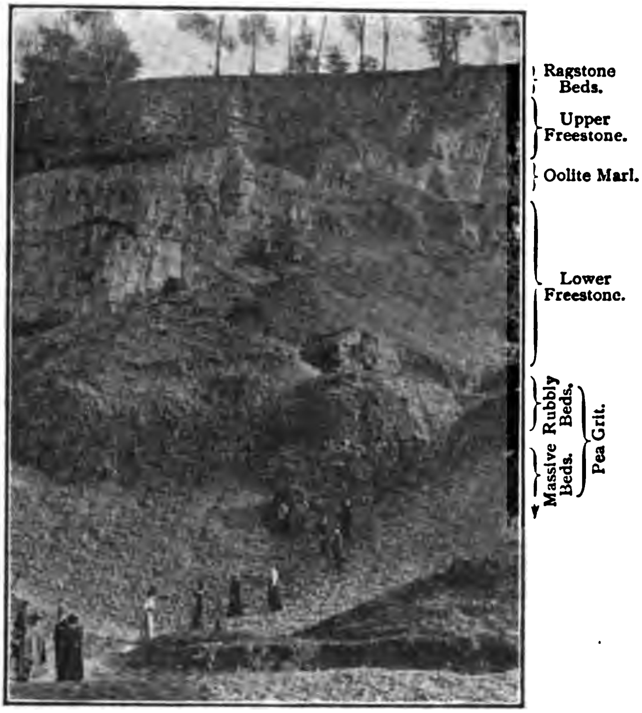

FIG. 39.—LECKHAMPTON HILL QUARRY.

(Photo by Prof. S. H. Reynolds.)

Reproduced from "A Handbook to the Geology of Cheltenham."

Before commencing the climb up the steep path alongside the quarry tram-line to the "middle jenny," the Director stated that they stood, roughly speaking, on the Marlstone of the Middle Lias, and that when they arrived at the "middle jenny" in the large quarry (Fig. 39) they would be on about the horizon of the Lower Limestone. In other words, they would have passed over the whole of the Upper Lias. At Leckhampton Hill the Upper Lias is about 230 ft. thick, and almost wholly clay. The top portion is somewhat arenaceous and very micaceous, and only at the very top here and there along this hillside is there a thin sand deposit lithically comparable with the Cotteswold Sands. At Stinchcombe Hill, near Dursley, however, while the Upper Lias is about 270 ft. thick, 230 ft. of it is sand—the Cotteswold Sands. At Bredon Hill to the north it is known that there is clay of the same date as portions of the Sands and Cephalopod Bed of more southern sections, so that it is quite possible that some portion of the Upper Lias clay at Leckhampton Hill is equivalent to some portion of the Cotteswold Sands at such places as Stinchcombe Hill.

Before studying the beds exposed in Leckhampton Hill a résumé was given of what is known concerning the Inferior Oolite rocks of the Cotteswold Hills between this hill and Wotton-under-Edge, in so far as it concerned the day's work.

In all some twenty-seven sub-divisions have been made of the Inferior Oolite of the West of England. From the Cotteswold Hills, in the maximum development, deposits of two hemeræ are absent, namely, of *Blagdeni* and *niortensis*. That reduces the sub-divisions recognisable in the Cotteswolds to twenty-five. In these hills, between the Upper Lias and a bed called the "Upper *Trigonia*-Grit," come nineteen of these, but not a single one of them is co-extensive with the hills.

Starting at the bottom, the *Aalensis*-Beds are best developed in the neighbourhood of Pen Wood, south of Stroud; the *Opaliniforme*-Beds range certainly from Haresfield to Old Sodbury; and the *Scissum*-Beds spread over the whole of the Inferior Oolite tract, except for a space contiguous to the Moreton Valley, where they are overstepped by the Lower Limestone; and south of Sodbury, where their outcrop is traversed by the Upper *Trigonia*-Grit. The top portion of the Lower Limestone of the Stroud district may be equivalent to the upper portion of the lower half of the Pea Grit of the Cheltenham district. At Leckhampton Hill the top portion of the Pea Grit is rubbly and its equivalent seems to be the Pea Grit of Selsley Hill, which there rests upon a somewhat eroded surface of the underlying Lower Limestone. South of Selsley Hill, at Frocester Hill and Coaley Wood, a thin bed, a few inches thick, is all that represents the Pea Grit, and even that cannot be definitely located in the Wotton-under-Edge area, where it is best to speak of the freestones as simply the "Freestone Beds." In the North Cotteswold, however, the Pea Grit is represented by the "Yellow Beds" or "Guiting Stone."

Above the Pea Grit, where it is well developed, is a Coral Bed —the "Fourth Coral Bed"—which is rich in micro-organisms.

The Lower Freestone has about the same geographical extent as the *Scissum*-Beds, and is best seen at Leckhampton Hill, where the coarser lower portion was called the "Roestone" by the earlier geologists. The Oolite Marl is essentially a Cotteswoldian deposit, but it is more clayey in some places than in others. At Leckhampton Hill it is more "rocky" than usual. Its geographical extent is not so great as that of the underlying Freestone, probably owing to a slight flexuring of the rocks in early *bradfordensis* times. At Wagborough Bush a horizon that is high up in the equivalent to the Upper Freestone at the Frith Quarry rests directly upon the Lower Freestone.* At Cleeve and Leckhampton Hills, of course, it is well developed; but at Birdlip it cannot be very definitely located. South of the Birdlip anticline, however, in Cranham Woods, it comes in again; at the Frith Quarry it is difficult to separate from the Upper Freestone; but at Selsley Hill there are limestones with marly partings on its horizon, and above beds referable to the Upper Freestone. By Frocester Hill it is gone, having been removed probably during the Bajocian Denudation.

About the close of the hemera *bradfordensis* crust-pressures were renewed, resulting in flexuring along the old lines of weakness. When the succeeding Ragstone Beds came to be deposited, the earliest of them had a certain geographical extent, not reaching south of Leckhampton Hill in the Cotteswold province. The Lower *Trigonia*-Grit had a wider range, its top portion overspread the Birdlip anticline, and most of the succeeding beds did so too. Then, however, occurred the Bajocian flexuring and denudation; the deposited rocks were thrown into anticlinal and synclinal flexures—the rocks in the synclines being preserved, according to the amount of their depression, and those on the anticlines removed, according to the amount of their elevation. The two main anticlinal axes were along the line of the Moreton Valley and Mendip Hills, meeting at right angles somewhere in the neighbourhood of the Marlborough Downs. A synclinal axis radiated along the line of Cleeve Hill: there was an anticlinal axis at Birdlip; a synclinal one near Painswick; but thence southwards, right away to the Mendip Hills, was the limb of an anticlinal flexure, with possibly a slight anticlinal roll in the neighbourhood of Dursley.

The Ragstone Beds between the Freestones and the Upper *Trigonia*-Grit have been called the "Intervening Beds." At Leckhampton Hill they are, in ascending order, the Lower

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* See *Proc. Geol. Assoc.*, vol. xviii, Pt. 8 (1904), p. 404.

Trigonia-Grit, *Buckmani*-Grit, Gryphite Grit, and Notgrove Freestone. These were investigated by the members, and the great number of annelid borings in the top portion of the Notgrove Freestone in the quarries on the summit of the hill caused general surprise. Above the Notgrove Freestone was seen the Upper *Trigonia*-Grit.*

After an inspection of the Firs-Brake section, where the much disturbed bottom-beds of the Inferior Oolite are seen above the Upper Lias clays, the members rejoined the brakes, making the next stop at the quarry on the east side of the road just beyond the "Air Balloon" Inn.† Here the top portion of the Freestone series and certain portions of the Lower *Trigonia*- and *Buckmani*-Grits were seen, and it was stated that on the evidence of the classic "Tuffley's Quarry" section, on the other side of the road, it was known that the succeeding deposit was the Upper *Trigonia*-Grit. So the Notgrove Freestone and Gryphite Grit have gone. Farther along the road in the direction of Birdlip, at the Cuckoo Pen Quarry, the Upper and Lower *Trigonia*-Grits are in apposition. The *Buckmani*-Grit has disappeared.

Leaving the quarry near the "Air Balloon" the road crosses the head of a small combe. The hard top-bed of the *Buckmani*-Grit can be followed from Tuffley's Quarry along the upper southern portion of this combe. Then comes a fault, for the *Clypeus*-Grit, which succeeds the Upper *Trigonia*-Grit, is seen in some old workings on the waste ground to be on a level with the Pea Grit Coral Bed. The effects of the fault are perhaps best seen on the east side of the road, for the Fullers' Earth, which throws off water at the head of the little combe, is below the level of the freestone exposed in the extensive, although now abandoned, quarries.

From the top of the rise there is a good view of the quarried face of Crickley Hill, in which the Pea Grit, with its overlying Coral Bed, is so admirably exposed (Fig. 40).

After lunch at the "George" Hotel, Birdlip,‡ at 2 p.m., the sections in the grounds of the hotel, and of "The Knap" (by kind permission of the late Mr. A. S. Helps) were visited.§

The first section examined was that on the hill-side nearest the hotel. It shows the succession downwards from the *Clypeus*-Grit to the Lower Freestone, and special stress was laid upon the fact that the Upper *Trigonia*-Grit here rests directly upon the Freestone without any intervening Lower *Trigonia*-Grit or other sub-division of the "Intervening Beds," and that there is also a non-sequence between the Upper *Trigonia*-Grit and *Clypeus*-Grit, the Dundry Freestone and Upper Coral Bed being absent.

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* For a detailed description of the Leckhampton Hill Section see *Proc. Cotteswold Nat. F. C.*, vol. xv, part 3 (1906), pp. 182-189.

† *Quart. Journ. Geol. Soc.*, vol. lix (1903), p. 384.

‡ It was at the "Black Horse," opposite the "George" Hotel, that the Cotteswold Club was founded in 1846, and held its jubilee meeting in 1896.

§ See also *Proc. Cotteswold Nat. F. C.*, vol. viii, part 2 (for 1883-84), pp. 161 *et seqq.*

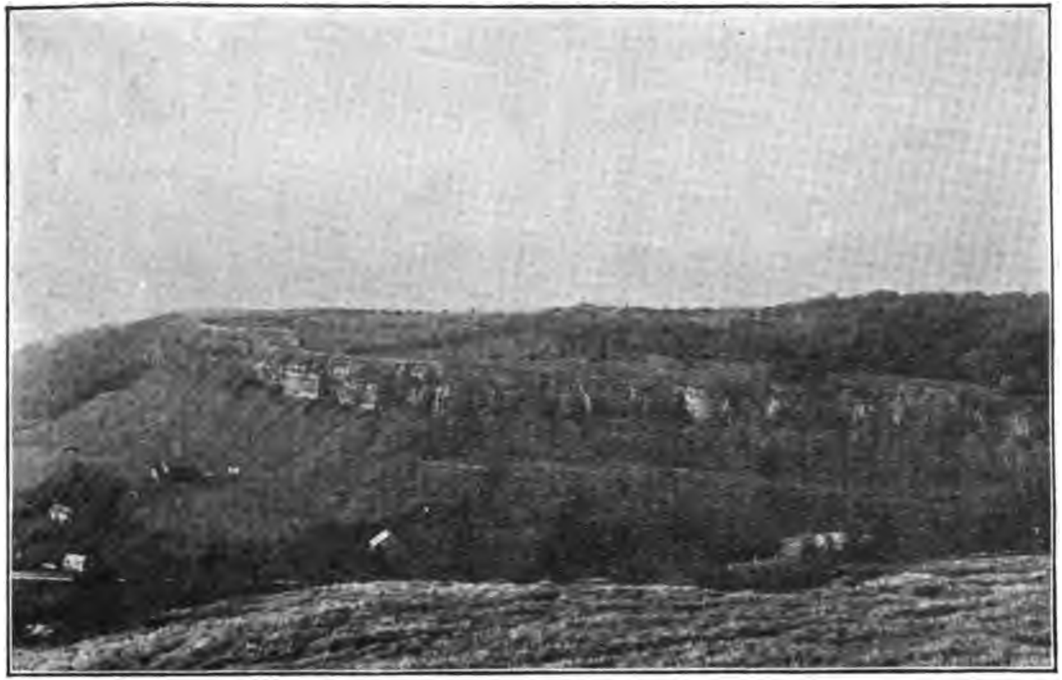

Photo by] Fig. 40.—CRICKLEY HILL. THE ROCK EXPOSED IS PEA GRIT. [*C. Upton*

Reproduced from "A Handbook to the Geology o Cheltenham."

The large quarry in the Freestone was not explored; instead the members proceeded to Mr. Helps's garden. On the way to "the cave" the Pea Grit Coral Bed was pointed out, and the underlying, and formerly extensively worked, Pea Grit, the top portion, as usual, being rubbly.

The dip being in a south-easterly direction older beds were successively traversed as the members proceeded in the direction of "The Peak," and the massive *Scissum*-Beds eventually came into view by the path-side with the Upper Lias below. But in a "cave" that Mr. Helps had excavated, and which the members entered, the junction of the two formations was far better displayed. Above is the very even under-surface of the massive *Scissum*-Beds; around the tough, bluish-grey clays of the Lias, very micaceous, and containing a ferruginous indurated band. Unfortunately no fossils have been found in this clay, and therefore even the approximate date cannot be definitely ascertained.

GENERALISED SECTION OF THE ESCARPMENT AT BIRDLIP HILL.

		Thickness. ft.	in.
[FULLER'S EARTH.	Indifferently exposed in the roadside on the top of the rise between Birdlip and the saw-mills]		
I.-III.—CLYPEUS GRIT.	Rubbly cream-coloured rock with pisolite-spherules of a pinkish or brown tinge; *Clypeus ploti* (very common), *Holectypus depressus*, *Terebratula globata*, auctt., non Sow., *Ter. globata*, var. *birdlipensis*, Walker, *Rhynchonella* spp., *Pleuromya goldfussi*, *Strophodus* (tooth), etc., seen in the section	6	0
	Limestones, whitish, oolitic, the top bed covered with oysters; *Terebratula globata* . . .	3	0
	Marl, yellowish, oolitic, crowded with *Ter. globata*, passing down into a rubbly limestone . . . . about	1	4
	Limestone, rubbly, not well exposed . . .	1	8
	Limestone, very massive, usually in two beds; rarely fossiliferous	3	0
NON-SEQUENCE.	Upper Coral-Bed and Dundry Freestone wanting.		
VI.—UPPER *Trigonia*-GRIT.	Ragstones, grey, shelly; top bed bored and covered with oysters; usual fossils . .	6	9
NON-SEQUENCE.	Deposits of *Blagdeni-concavi* hemeræ wanting.		
(?) UPPER FREESTONE.	Limestone, white, oolitic, flaggy. Top bed slightly bored in places, with oysters adhering; *Terebratula fimbria* 15 inches from the top	4	0
(?) OOLITE MARL.	Limestone, softer than the bed above, and of a yellower colour	8	0
	Marl, yellowish, oolitic	0	1
	Limestone, rubbly in the centre; *Rhynchonella* of the *Rh.-witchelli* type	1	5
	Marl, yellowish, oolitic; *Terebratula fimbria* (rare), *Rhynchonella* (fragment), "no micro-organisms" (C. Upton, *in litt.*) . . .	0	1

		ft.	in.
LOWER FREESTONE.	Limestone, white, oolitic; top bed well planed and slightly bored. Seen in the large quarry . . . . . . about	60	0
	"Fissile Oolite" (*teste* Lucy)	10	0
PEA GRIT.	Coral Bed. A whitish, rubbly, usually non-oolitic limestone, full of corals; (?) *Isastræa richardsoni*, *Kobya terquemi*, *Thecosmilia rugosa*, *Cosmoseris incrustans*, *Isastræa* aff. *limitata*, *Isastræa flemingi*, *Thamnastræa defiancei*, *Heteropora conifera*, etc. . .	15	0
	Limestone, made up of pisolite-spherules, compact in some places, rubbly in others. The rubbly beds occur at the top; the lower beds are massive, and less pisolitic and fossiliferous. The lowest bed is a massive limestone, 7 feet thick; *Cidaris bouchardi*, *Cidaris fowleri*, *Stomechinus intermedius* var. *germinans*, *Pygaster semisulcatus*, *Pseudodiadema depressum*, *Littorina* cf. *recteplanata*, *Haplæcia straminea*, *Lymnorella inclusa*, usual brachiopods and pelecypods	60	0
Scissum-BEDS.	Limestone, hard, coarse, yellowish-brown, sandy; belemnites numerous on the under surface, but difficult to extract. *Rhynchonella subdecorata*, *Terebratula*, sp. nov.; *Trigonia*, *Gresslya*, *Pholadomya*, and *Ceromya* (*teste* Lucy)	7	0
UPPER LIAS.	Clay, bluish-grey, very micaceous, seen . .	6	0

Leaving Birdlip, a quarry near the saw mills was passed, where the Upper *Trigonia*-Grit rests upon the Freestone, and a mine on the right in which the Lower Freestone has been worked beneath the Oolite Marl, which has come in again. The first halt, however, was at the Buckholt Wood Quarry, where the Upper *Trigonia*-Grit rests upon the Gryphite Grit, with the *Buckmani* and Lower *Trigonia*-Grits below. So three members of the "Intervening Beds" have come in again, which shows that a synclinal area has been entered.

After tea at the "Falcon" Hotel, Painswick, at 4 p.m., the members walked across to "The Frith." Mr. Charles Upton had joined the party at Painswick, and undertook the explanation of the sections here. First he led the way into a quarry in very unpromising-looking, rubbly, lime-washed beds, which, he said, contained a great number of micro-organisms, but required considerably more attention before anything like a complete list could be produced.

The beds are on the horizon of the Pea Grit Coral Bed.

Entering the quarry called "The Frith Quarry," the peculiar marly beds which here represent the Oolite Marl and Upper Freestone were pointed out, and a large number of examples of *Rhynchonella cynomorpha* and *Rh. tatei* were collected from near the top. The Lower *Trigonia*- and *Buckmani*-Grits were also pointed out, but time pressed, and the visit to Worgan's Quarry had to be abandoned. Worgan's Quarry exhibits a magnificent development of the Upper Coral Bed, which has yielded a large number of echinoids and micro-organisms,* resting upon the Upper *Trigonia*-Grit.

WORGAN'S QUARRY, NEAR STROUD.

		Thickness.	
		ft.	in.
IV.—UPPER CORAL BED.	Rubbly white oolite, mixed with marly clay (especially near the base) and having two well-defined lines of coral, *Isastræa* sp., *Amberleya hudlestoni*, *Pleurotomaria* sp. (very depressed form), *Solarium* cf. *subvaricosum*, *Rhynchonella subtetrahedra*, *Terebratula lentiformis*, *Zeilleria waltoni*, common, *Magnosia forbesi*, *Pedina rotata*, *Polycyphus normannus*, *Pecten* (*Chlamys*) *articulatus*, etc., *Spiriferina* ? *oolitica*, and other micro-brachiopods, foraminifera and ostracoda	6	0
NON-SEQUENCE.	Dundry Freestone wanting.		
VI.—UPPER *Trigonia*-GRIT.	Ragstone, shelly, layer of oysters on the top and bored ; usual fossils : seen	4	0

Stroud was reached at 7 p.m.

The tract of country between Stroud and Uley Bury was also investigated.

From the hotel the members drove to the Lightpill brick works, by the side of the Bath Road, where the Middle Lias is well exposed, and thence on to Dudbridge.

Arrived at Dudbridge Station, the Director said they were on the *Capricornus*-Beds of the Middle Lias, for beds of impure limestone, precisely the same as regards faunal and lithic characters to the contemporaneous beds that were exposed in the railway cutting at Old Sodbury, and in the pit at Pilford, Cheltenham, had been laid bare during the making of excavations at Messrs. Kimmins, Drew & Co.'s offices close to the station, and in the station-yard itself. In ascending the hill they would pass over the Middle and Upper Lias, and see the Lower Limestone of the Inferior Oolite in a quarry on the edge of the Common. Edwin Witchell has described the geology of this hill in some detail,† and this is his "No. 6." It shows an interesting development of the Lower Limestone since that limestone frequently contains rounded pebbles of oolite, presumably the products of a penecontemporaneous erosion.

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* See *Quart. Journ. Geol. Soc.*, vol. lxiii (1907), pp. 413-414.

† *Proc. Cotteswold Nat. F.C.*, vol. ix, part 2 (for 1886-87), pp. 96-107.

Quarry in the Lower Limestone, Selsley Hill.

		Thickness.	
		ft.	in.
Lower Limestone	Limestone, oolitic with a conspicuous, partly white bed at the base: seen	4	0
	Rubbly bed, average	0	4
	Limestone, fairly regular bed	0	7
	Limestone, finely-oolitic, with coarser oolite-granules in lines, giving the rock a streaked appearance, often a "Dapple Bed"	4	0
	Limestone, "Dapple Bed"	2	2
	Limestone, massive, "Dapple Bed"	3	4
	Limestone, massive, in places a "Dapple Bed." Has yellow granules and crowds of echinoid-radioles and *Pentacrinus*-ossicles; *Ostrea* cf. *costata*: seen	5	0

In the next quarry (Nos. 4 and 5 of Witchell), which is quite close, the top portion of the Lower Limestone is visible with the Pea Grit above, and this is followed by one—at a distance of about 300 yards—in which the top portion of the Lower Freestone, the Oolite Marl, Upper Freestone, and bottom portion of the Upper *Trigonia*-Grit are seen. As brought out in the following record the beds placed on the Oolite Marl horizon are subject to considerable variation. It should be particularly noticed that there are no Lower *Trigonia*- or *Buckmani*-Grits between the Upper Freestone and Upper *Trigonia*-Grit as at Rodborough Hill. In the south-eastern portion of the quarry is a trough-fault, Ragstone Beds being introduced.

Quarry in the Freestone Series, Selsley Hill.

		Thickness.	
		ft.	in.
Upper *Trigonia*-Grit	Ragstone, shelly; usual fossils: seen	2	6
Non-Sequence.	Deposits of *Blagdeni-concavi* hemeræ wanting		
Upper Freestone	Oolite, thin-bedded, flaggy	12	3
Oolite Marl.	Limestones, with an undescribed species of *Rhynchonella*, *Terebratula fimbria*, *Rhynchonella granulata*, and *Lima semicircularis*, and layers of shaly marl, subject to much variation. Specimens of *Lucina*, *Acrosalenia* and *Hemipedina tetragramma*, found on the spoil heaps, probably from this horizon: 1 foot 9 inches to 4 feet	2	0
	Marl, brownish, oolitic, with pebbles at the base; *Rhynchonella subobsoleta*, *Terebratula fimbria*, and *Cypricardia*	0	4
Lower Freestone.	Limestones, massive, oolitic: seen	7	0

In Witchell's time about 7 feet more of Lower Freestone were exposed. He remarked that "it is rather singular that so little of the Freestone should have been worked in this hill, as the beds must be 70 ft. thick.

Between this quarry—which is No. 2 of Witchell—and the tumulus is a shallow quarry (No. 1 of Witchell) in the Ragstone Beds. The top bed of the Upper *Trigonia*-Grit is easily recognised by the number of oysters that are adherent to it and by its bored condition. This "Grit" is known, on the evidence of the last section, to rest directly upon the Upper Freestone; there is no Gryphite Grit in between as Witchell thought. It is true that he remarked, "the Gryphite Grit appears to be changing from its usual ferruginous aspect to that of the [Upper] *Trigonia*-Bed, and from the absence of its most characteristic fossils it is difficult to identify it."

Above the Upper *Trigonia*-Grit is a bed of very distinctive lumps of limestone containing *Terebratula subsphæroidalis* and a new species of *Rhynchonella*. Mr. C. Upton has washed some of the marl associated with these limestone masses and records Ostracoda and Foraminifera. Rubble of typical *Clypeus*-Grit succeeds.

The features of the surrounding country were pointed out from the top of the tumulus, which is 689 ft. above Ordnance Datum, and an interesting discussion on River Development took place, in which the President, Mr. Whitaker, Dr. A. Vaughan, and Dr. Cullis took part. The Director then called attention to the fact that the sequence they had been studying was completed at Bown Hill, which is an outlier of Fuller's Earth and basal Great Oolite beds.

Magnificent views over the vale were obtained during the drive along the edge of the hills, and when the ever-breezy Frocester Hill was reached the flat-topped Cam Long Down attracted particular notice. Few views are more inspiring than this one.

First the exposure by the side of the main road of the Cephalopod Bed with the overlying *Opaliniforme*- and *Scissum*-Beds was investigated, and then the large quarry in which Lower Limestone, the thin layer on the horizon of the Pea Grit, and lower portion of the Lower Freestone are seen.

After an *al fresco* meal the members passed on to Uley Bury, first examining the large quarry in which the thin rubbly layer representing the Pea Grit is seen amid the freestones, and then descending to the section of the Cephalopod Bed. The sections here are much the same as at Frocester Hill, so, after a brief inspection, the members returned to the entrance of the Uley Camp, where the Director outlined the history of closing British times and the early years of the Roman occupation.

A visit to the far-famed Uley tumulus, which was entered, completed the day's work, and after tea at Nympsfield the drive back to Stroud was by the same route as that traversed during the morning—along the escarpment.

On Monday the members left Stroud (M.R.) at 10.10 a.m., and arrived at Charfield at 10.58 a.m. From the station they drove to Wotton-under-Edge.

Passing through Wotton, they ascended Wotton Hill to study the sequence of Inferior Oolite beds as developed in this part of the Cotteswold Hills.

The first section examined was that well known for its fine exposure of the Cephalopod Bed, which is seen above the Cotteswold Sands and below the *Scissum*-Beds. The *Striatulum*-Beds at the base, comprising two fairly massive beds of impure limestone separated by a shaly parting, were pointed out, and particular stress was laid on the fact that since they overlaid the Cotteswold Sands those Sands were pre-*striatuli*. Farther south, at "The Springs," Dodington, *Grammoceras striatulum* occurs *in* the sands, and at Timsbury Sleight, in Somerset, *below*.

Continuing up Wotton Hill the large quarry in which the Freestone Beds have been so extensively worked was visited. These Freestone Beds succeed the *Scissum*-Beds of the previous section, and while they mainly represent the Lower Limestone it is just possible that one of the rubbly layers represents the Pea-Grit band of the Frocester-Hill section, which would make the portion of the Freestone above referable to the Lower Freestone. Resting upon the bored and waterworn surface of this freestone is a feeble representative of the Dundry Freestone, succeeded by a not much more conspicuous development of the Upper Coral Bed. Above come beds which must be referred to the Upper *Trigonia*-Grit, although scarcely typical of that sub-division, succeeded by readily recognisable *Clypeus*-Grit.

The main object of visiting these two sections was to demonstrate (1) that the Cotteswold Sands are of pre-*striatuli* date, and (2) that between the *Scissum*- and Ragstone Beds come only Freestone Beds—no Oolite Marl, Upper Freestone, or any of the "intervening beds." The Director stated that if they examined the sections between here and Bath they would find that even the Freestone Beds disappeared, so that in the neighbourhood of Bath the Upper *Trigonia*-Grit rests directly upon the Sands. But north, as they were now aware, there was a general thickening as far as the neighbourhood of the Moreton Valley, although beds appeared and disappeared according to the results of the Bajocian flexuring and denudation.

Before turning into the woods the position of the Fullers' Earth and Great Oolite was indicated, so that in the neighbourhood there is a complete sequence from the Lower Lias below Wotton to the basal beds of Great Oolite on Symond's Hall Hill.

Passing through Westridge Wood the members came out on the scantily grass-clothed Nibley Knoll, which is rendered conspicuous from the vale by the monument erected to Tyndale, the translator of the New Testament.

After the Director had explained the geography and geology of the scene before them, Prof. S. H. Reynolds contributed some remarks on the country to be traversed during the following day around Tortworth, which was clearly visible down in the vale. Mr. Whitaker added some observations, and then the neighbouring quarry in the Freestone and Ragstone Beds was briefly studied. It shows the basal portion of the *Clypeus*-Grit, all that represents the Upper *Trigonia*-Grit, and—as at Wotton Hill it is thin—the Upper Coral Bed, with the Freestone Beds below.

The lane down to North Nibley is deeply excavated in the sands, and reveals the Cephalopod Bed high up in the bank on the left. As the component deposits precisely resemble their equivalents at Wotton Hill, the section was left undisturbed, and the members made direct for the "White Hart" Hotel, where lunch was served.

After lunch the route lay partly up and then across the deep Waterley Bottom, a combe typical of those that characterise this part of the Cotteswold Hills. The lane then followed, after crossing the stream north of Fording Brook, was that past the "New Inn," and in its banks is afforded the finest section of the Cotteswold Sands in the Cotteswold Hills. The lane is deeply cut and near its very commencement are some hardish sandstone bands intercalated in the sands. They yielded a few specimens of *Haugia*, thereby dating the portion of the Sands in which they occurred as *variabilis*. Near the top of the lane the Cephalopod Bed was seen, but except that some of the layers are slightly harder, it agrees with the equivalent at Wotton Hill and Nibley Knoll, and therefore requires no detailed notice.

While the members were resting the Director gave a final discourse on the Sands, which are so frequently found to constitute a greater or less portion of the Upper Lias or Toarcian. Starting with what they knew, they had now seen sufficient to agree that the Cotteswold Sands were pre-*striatuli*, and of about *variabilis* and *Lilli* hemeræ. At Timsbury Sleight, not a great way from Radstock, in Somerset, the Midford Sands were post-*striatuli*—indeed, post-*Struckmanni*, and probably of *dispansi* hemera. In brief, at the Wotton section the *Striatulum*-Zone comes *above* the sands, and at Timsbury Sleight *below*. The pre-*striatuli* sands are the Cotteswold Sands; the post-*striatuli* sands the Midford Sands. Between the two areas in which these phenomena are so evident, is one in which the *Striatulum*-Niveau comes *in* the sands, which are therefore—in part at any rate—of the hemera *striatuli*. This is the date of the sandy, shaly deposits above the Alum Shales and below the "Grey Beds" of the Blea Wyke or Ravenscar section in Yorkshire. The Yeovil

Sands are of *Moorei-Dumortieriæ* hemeræ; the Bridport Sands still later—late *Dumortieriæ*, *Moorei*, *aalensis* and *opaliniformis* hemeræ. So the equivalents of certain of the component layers of the Gloucestershire Cephalopod Bed are in certain parts of Somerset and Dorset sands of considerable thickness. These facts demonstrate the uselessness in such cases of relying upon similarity in lithic structure as proof of contemporaneity, and they are further emphasised by the deposits of *Lilli* date, which are sands and sandstones at Coaley Wood, being clays near Cheltenham.

At Break Heart Hill the quarry in the Freestone and Ragstone Beds was briefly inspected. It is the one concerning the date of the freestone of which Mr. H. B. Woodward was in some doubt.*

BREAK HEART HILL QUARRY, NEAR DURSLEY.

		Thickness. ft.	in.
UPPER *Trigonia*-GRIT.	Ragstone, shelly; usual fossils: seen	3	0
NON-SEQUENCE.	Deposits of *Blagdeni-bradfordensis* hemeræ wanting.		
FREESTONE-BEDS (*Murchisonæ*).	Limestone, oolitic, not well bedded	4	2
	Parting	0	1
	Limestone, false-bedded in the upper portion, and having a very regular top: seen	10	0

Returning to the road, a short walk in a north-westerly direction brought the members to a slight rise, where Fullers' Earth clay was seen in the road sides, and, in some trenches over the hedge, some of the limestone bands (almost made up of the valves of *Ostrea acuminata*), which are a well-known feature of the Fullers' Earth in this part of the Cotteswolds. A small pond in the wood at the junction of the lane leading down Warend Hill further indicated the presence of the argillaceous Fullers' Earth.

Continuing their walk along the road the members came out on the golf course on Stinchcombe Hill, which they crossed to the part that lies between Bownace and Hillside Woods. From this spur, which commands the most magnificent views of the Lower Severn Valley, the Director indicated the part the various rocks played in producing the varied country within their view. Then he proceeded to give a more detailed description of the structure of Stinchcombe Hill itself. First comes the Lower Lias that forms the "solid" floor of the vale; then the Middle Lias, with its hard cap of Marlstone that has given rise to the marked tabular platform upon which the houses of the hamlet called "The Quarry" are built, which is followed by the slope of the Upper Lias, here mostly made up of sand (Cotteswold

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* "The Jurassic Rocks of Britain," *Mem. Geol. Surv.*, vol. iv (1894), p. 108.

Sands), with the Cephalopod Bed at the top. Finally comes the steep scarp of the Inferior Oolite rocks. The accompanying section (Pl. XXVIII, Fig. 2), will explain the succession far better than words. The Fullers' Earth probably occupies some hollows on the summit, as the ground is distinctly clayey in places.

Immediately below the Fullers' Earth come the Rubbly Beds. These beds and the underlying White Oolite (the *Anabacia*-Limestones of the Bath-Doulting district), *Clypeus*-Grit (Doulting Stone of the same area), and Upper *Trigonia*-Grit, are best seen in a quarry on the east side of Hollow Combe, which has been called the "Stancombe Quarry." Time did not permit of a visit to this quarry, but the following notes may not be out of place.

The quarry is divided into two parts, a northern and a southern, by a grassy bank that indicates a line of fault, the Upper *Trigonia*-Grit of the southern portion being on a level with the *Clypeus*-Grit of the northern. The Rubbly Beds are seen just below the turf in the northern portion, and are replete with specimens of *Terebratula globata*, auctt. non Sow., while *Holectypus depressus* is less common. Below are somewhat sandy-looking, rather barren, limestones, with occasional specimens of *Acanthothyris spinosa* and *Terebratula globata*, representing the White Oolite, that are followed in descending order by beds referable to the *Clypeus*-Grit. The bottom portion of the *Clypeus*-Grit is seen in the southern section of the quarry parted by a marly deposit from an oyster-covered surface of the underlying Upper *Trigonia*-Grit. The marly layer is on the horizon of the Upper Coral Bed, and has yielded several interesting echinoids, but the Dundry Freestone is not represented. The Upper *Trigonia*-Grit is of the normal type—a very shelly ragstone—but it is better seen in the abandoned quarry on the spur between Bownace and Hillside Woods. The members afterwards visited this section, from near which is one of those magnificent views over the valley. Pointing to where a new house was being erected in Hillside Wood, the Director said it was there, from marly bands apparently on the horizon of the White Oolite, that he obtained specimens of clay that had yielded to Mr. Upton an extraordinary number of micro-organisms.

Commencing the descent of the hill, in the bed of the road near the end of the wall above the gravel-pit is seen the Cephalopod Bed, and then all the way down, almost to the Marlstone platform, is abundant evidence of the Cotteswold Sands.

A visit was paid to the gravel-pit. It is situated at about the 500-feet contour-line. The Director remarked that it was noteworthy that, whereas from that point northwards such gravel-beds were not infrequent at all altitudes on the hill-slopes, and superficial deposits were distributed far and wide over the vale land, from thence southwards to the Avon Valley no such accumulations had attracted his attention. It opened out an interesting question, to solve which, however, more details were required.

Turning at the "Yewtree" Inn along the Oldhill Lane, the large quarry in the Marlstone was entered. The Marlstone is from 15 to 20 ft. thick here and is crowded with *Rhynchonella amalthei* and belemnites.

Tea at "The Welcome," Cam, completed the day's proceedings, and the members left by the 7.5 p.m. train for Stroud.

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PART II. BY PROF. S. H. REYNOLDS.

Tuesday, June 9th, 1908.—The party numbering forty left the train at Wickwar Station, which lies immediately to the north of the tunnel penetrating the horseshoe-shaped ridge of Carboniferous Limestone bordering the Bristol Coalfield. The first stop was made at a small quarry in Old Red Sandstone of the usual character—red and grey sandstone often micaceous, with bands of quartz pebbles, and the Director drew attention to the remarkable attenuation of the Old Red in this region, where it is only 200 or 300 ft. thick, this fact, together with the thin and imperfect development of the Ludlow Beds, being probably best explained on the view that the district was upheaved and subjected to erosion during the late Silurian and early Old Red times.

Several quarries in the Carboniferous Limestone were next visited, and the various sub-divisions which have been established in these rocks by the work of Dr. Vaughan were pointed out. The first two quarries were opened in the upper part of the *Zaphrentis* Beds (Z_2) and the succeeding horizon γ, the lower *Zaphrentis* Beds (Z_1) and *Cleistopora* Beds (K) not being exposed. The lower beds in each quarry are highly fossiliferous, and many specimens were obtained. The highest beds exposed—best seen in the second of the two quarries—are the *Laminosa* dolomites, the lowest beds of the *Syringothyris*-zone (C). The dolomites are not due to subsequent dolomitization, but are original and indicate the prevalence of shallow water conditions.

A third quarry showing the *Caninia* oolite of the upper *Syringothyris*-zone was not visited, and the party proceeded at once to a large quarry in the *Seminula* beds (S_1 and S_2). Patches of *Lithostrotion martini*, bands of *Seminula* shale with *Productus*, in the lower beds, and the fine oolite in the upper beds received attention, and it was pointed out that here in the lower part of the Upper Carboniferous Limestone of the district, while the number of individual fossils is very great, the number of species occurring is relatively small.

Joining the brakes, the party then drove to Charfield, where a halt was made for refreshment. The members then walked to Cullimore's Quarry, which had been newly opened up, showing a thickness of some 2½ ft. of ashy limestone of Upper Llandovery age, which is seen resting on the surface of the highly amygdaloidal trap. Occasion was taken to summarise the various views which have been held with regard to the igneous rocks of this district.

It had been proposed to walk along the Little Avon from Avening Green to Damery, but this had to be omitted owing to lack of time, and the party drove straight from Charfield to Damery, where the old quarry in the Llandovery on the south side of the river is the most noted fossil locality in the district, and as it had been recently opened up, material was plentiful and many fossils were obtained. The large trap quarry, the only one in the district now in work, was next visited, and here a photo of the party was taken by Miss Johnston. After a short drive the majority of the party left the brakes and walked across the fields to Middlemill Quarry, which had also recently been opened up and showed several feet of hard limestone containing scattered lapilli of considerable size with numerous corals and other fossils resting on the top of the trap. The Director pointed out that when the quarry was visited by the Association in 1901 it was believed that Middlemill Quarry was situated in the lower of the two trap bands which occur associated with the Llandovery rocks, and that consequently the lower band was thought to be like the upper, overlain by a band of ashy limestone. Further work led to the conclusion that the Middlemill trap belonged to the upper band, and that consequently much of the evidence cited for the contemporaneous character of the lower trap band no longer held good.

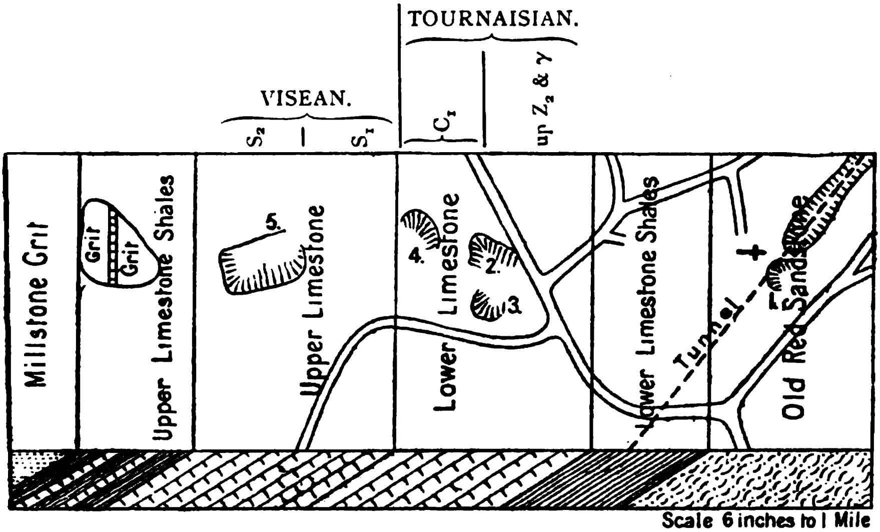

FIG. 41.—SKETCH MAP AND SECTION OF WICKWAR QUARRIES.
C. Lloyd Morgan.

The brakes were here entered, and the party drove through the villages of Stone and Falfield to Whitfield, where a hurried visit was made to the old Whitfield or Brinkmarsh quarry, from which very large numbers of Wenlock fossils have been obtained in former times. Part of the quarry had been recently opened up, and showed a thick series of shales with plentiful corals (*Hallia mitrata*) and brachiopods (*Orthis basalis*), overlying alternating limestones and shales, three of the limestone bands being more or less completely replaced by celestine. Here Dr. Vaughan joined the party, who, through the kindness of Lord Ducie, were enabled to drive back to Charfield through the beautiful Tortworth Park. Tea was obtained at the "Railway" Tavern, and a vote of thanks was accorded the Director.

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EXCURSION TO KNOCKMILL (OAKLANDS) AND COTMAN'S ASH.

SATURDAY, JUNE 13TH, 1908.

Directors: R. H. CHANDLER and A. L. LEACH.

Excursion Secretary: MISS M. S. JOHNSTON.

(*Report by* THE DIRECTORS.)

THE party, twenty-four in all, met at Kemsing Station at 2.32 p.m., and walked towards the Downs, following for a short distance the "Pilgrims' Way," which here remains in use as a high road. In a short description of this ancient, historic (and probably prehistoric) trackway the Directors referred to its present condition, and to the various theories which seek to explain its origin. Entering the fields above St. Clere the party climbed the Chalk scarp to the corner of Birches Wood, whence a fine view was obtained.

To the south beyond the Gault valley (Holmesdale) the thickly-wooded "Greensand ridge," rising to 700 ft. O.D., shut out the Weald except where through the gap of the Shode the "Forest Range" (Hastings Sands) was seen at a distance of seventeen or eighteen miles. Parallel to the "Greensand ridge" the chalk escarpment was finely shown from Titsey Hill on the west to the North Downs above Hollingbourne on the east. Far to the west the President recognised Leith Hill nearly thirty miles away.

A peculiar river-system, immediately to the south, next claimed attention. The upper basin of the Shode (an anti-dip stream) is bounded on the north by the Chalk range, on the east and west by gentle rises (in the Gault), which are transverse to the Gault valley and form the water-partings between a westward-flowing strike-tributary of the Darent and the Leybourne, another strike-stream which flows eastward into the Medway. These Gault water-partings at their lowest points rise to about 320 O.D.; the chief springs of the Shode issue, on the north, probably from the base of the Chalk marl about 380 O.D., and from the Lower Greensand above 400 O.D. The Shode, after breaching the "Greensand ridge" by a cañon-like gorge south of Boro' Green, joins the Medway at Hadlow in the Weald Clay, thus presenting the very unusual feature of a stream flowing southward into the Weald. Topley, to account for the anti-dip course of the Shode, assumed an anticline in the Shode Valley, by which the outcrop of the Weald Clay would be thrown farther north; by the denudation of this clay and the recession of the head of the valley thus formed, he thought the present configuration might have arisen. Recently, however, Mr. W. J. L. Abbott has shown the existence of a syncline in the Shode gap. The Shode enters Weald Clay at Plaxtole, 150 O.D., whilst immediately to the east the Hythe Beds and Atherfield Clay rise to 550 O.D. at Hurst Hill, and to nearly 700 O.D. at Shingle Hill on the west. Allowing 150 ft. for the combined thicknesses of the Hythe Beds and Atherfield Clay (an over-estimate) there still remains a syncline of 300 ft. or so.

Mr. F. C. J. Spurrell suggested that a reversal of drainage had occurred in the Shode valley, whereby a stream once flowing into the Darent from the "Forest Range," had become tributary to the Medway. This view is negatived by the evidence of the Shode gravels, which contain flint and chert in abundance, but yield no Wealden material above Dunk's Green, which is well within the Medway system.

Whilst, therefore, the Shode Valley presents many interesting features, the Directors regard it as due to the recession of the head of an anti-dip stream. Similar, but less advanced, anti-dip streams occur at Oxted, Godstone, and Redhill.

After a pleasant walk through Birches Wood, a pit in an outlier of Blackheath Beds at Oaklands (Knockmill), was reached, where, at 727 O.D., a depth of 20 ft. of sandy gravel is shown. The deposit consists mainly of flint pebbles and sand, but siliceous conglomerates occur in an old pit close at hand, and the Directors had obtained, also, one quartzite pebble. Two features in this pit require explanation. (1) The disturbed condition of the pebble-beds. (2) The presence of a mass of sand and "silica powder" full of flint pebbles, as white, and almost as soft, as chalk.*

1. The tumbled state of the pebble-beds is probably due to their slow descent into "pipes" formed by the solution of the subjacent Chalk. Evidence for the existence of these "pipes" is

* See Fig 42 and Plate XXIX.

supplied by (*a*) the present drainage of the pit. From the lowest point of the pit-floor an iron pipe runs into loose "pea-gravel." No water accumulates as long as this pipe is kept open, but if the passage to the "pea gravel" becomes blocked, water may lie in the pit to a depth of two or three feet. This indicates the existence of a "water-sink" in the chalk below the pea gravel, and in this part of the pit there is a deep hollow in the pebble-beds, filled with loamy drift. (*b*) Excavations at Oaklands. In digging out a tank the top of the chalk was found to be very irregular. (*c*) Comparison with the Worm's Heath outlier, where similar, but even more greatly disturbed pebble-beds occur high up on the Downs (about 750 O.D.); deep "pipes" in the chalk are well shown beneath the Tertiaries, and the evidence of subsidence is clear. Probably the Oaklands outlier, like that of Worm's Heath, rests directly on the chalk, but this cannot be proved until the pit is excavated to the base of the pebble-beds.

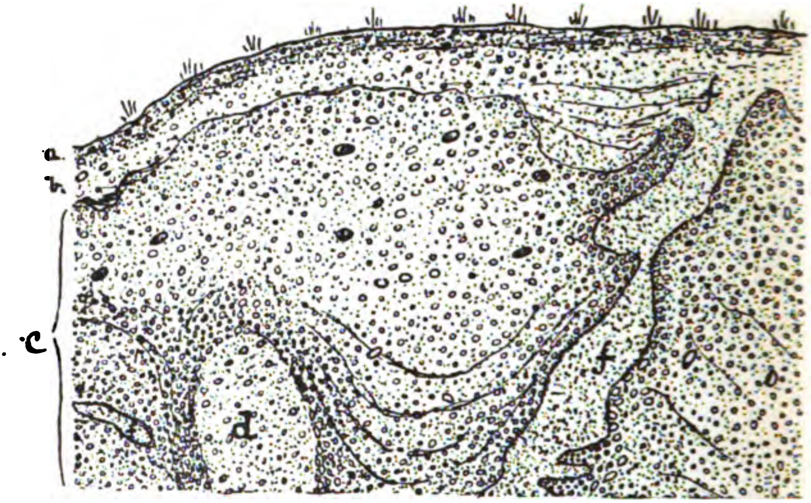

FIG. 42.—SECTION IN THE BLACKHEATH BEDS OF THE OAKLANDS OUTLIER (KNOCKMILL).—*A. L. Leach.*

Scale 10 ft. to 1¼ inches.

a. Pebbly soil, 1-2 ft.
b. Sand and pebbles, 2-4 ft., with irregular streaks of clay.
c. Pebble Beds, 15-20 ft. (base not seen), all much disturbed.
d. Mass of white sand with whitened flint pebbles.
f. Sand, passing down into a "pipe" in the gravel.

2. The white siliceous mass* rises from the floor of the pit

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* See Plate XXIX.

like a mound of chalk, for which it might easily be mistaken. It contains: (*a*) A milk-white angular quartz sand. (The ordinary sand of the pit is yellow to brown, from the presence of iron.) (*b*) A pure white siliceous powder, so fine that it will remain suspended in water for several hours. (*c*) Many flint pebbles pure white throughout.

The complete bleaching of the flints is probably due to the removal of "soluble silica" and the colouring matter by the solvent action of percolating water. Flints showing a white cortex one-eighth of an inch to three-quarters of an inch in depth commonly occur in chalk quarries, in "pipes," and on the open Downs. That this cortex is porous may be demonstrated by dipping the flints in red ink, which is readily absorbed by *the cortex.* Some flints from "pipes" on Worm's Heath, showing a cortex one-half inch deep surrounding dark unaltered flint, absorbed the colouring matter readily throughout the cortex, but the dark core remained unaffected; the Knockmill pebbles become stained through and through. Evidently the porosity of the altered flint is due to the removal of "soluble silica," and the solvent has removed also the iron and manganese which impart the dark colour to ordinary flints. At Knockmill there are pebbles showing every stage of the process, from those with merely a film of white cortex to those in which the "whitening" has reached the centre, and the whole pebble resembles a lump of chalk.

The "silica powder," which is the final result of the decomposition and disintegration of these pebbles may easily be separated from the accompanying bleached sand by levigation; under the microscope it can readily be distinguished from the quartz grains by its excessive fineness.

The occurrence of such a mass of disintegrated flint seems to be very unusual. While the alteration is simply a continuation and completion of the ordinary "bleaching" of flints, for which the solvent action of water (more or less carbonated) is held a sufficient cause, it is not easy to see why the alteration has been so complete in only a very limited part of the pit, and while downward percolation seems the most obvious course for the active solvent the possibility of water (charged slightly with alkaline carbonates) rising from the Chalk is certainly worthy of consideration.

After an examination of this interesting pit a shallow trench, recently opened by Mr. B. Harrison, in the adjoining wood was visited. Here a few sub-angular brown flints were seen mixed with the Tertiary pebbles. From this sparse "drift," which occurs on the highest part of the Tertiary outlier, Mr. Harrison has obtained flints of "eolithic" type.

The party now walked past Oaklands, noting a fine view of the Maplescombe valley; in the distance were seen Well Hill, Shooter's Hill, and the Essex hills, all capped with drifts containing Lower Greensand chert.

From a spur below Whitegate Cottage (where a modern "dew pond" was noted) an excellent view was obtained of the Maplescombe Valley with its many tributary valleys. Through a "wind-gap" at the head of the main valley the "Greensand ridge" in the neighbourhood of Knole Park was clearly seen. The significance of this "wind-gap" was remarked on by the Directors, who regard it as part of the valley of an old dip-stream flowing from the south along the line of the present Maplescombe Valley before the excavation of the Holmesdale Valley.

Time would not permit more than a hurried examination of the upper part of Maplescombe Valley. The walk was continued towards Cotman's Ash and over the crest of the Downs. In a deep "coombe" in the escarpment a well-marked terrace was indicated. Traces of others were noted lower down the coombe, and three parallel terraces were crossed as the party descended the escarpment to Kemsing. The Directors regard these as "cultivation terraces" (lynchets), and this view was supported by several members of the party.

After tea at the Bell Inn, Kemsing, a vote of thanks to the Directors was moved by the President, and they were asked to express the thanks of the Association to Mr. F. Sugden and Sir Mark Collett (through Mr. F. Capper) for permission to walk through their properties.

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EXCURSION TO AVEBURY AND WINTERBOURNE BASSETT.

Saturday, July 4th, 1908.

Director: Rev. H. G. O. Kendall.

Excursion Secretary: Mark Wilks.

(*Report by* The Director.)

A party of eight left Paddington by the 9.35 for Marlborough, where they were joined by four others. Marlborough College was first visited, and the fine proportions of the Chapel as well as the architecture of C. House, with its oak carving, were duly admired. "The Mound" is similar to Silbury Hill and to the mound at Oxford. All three were possibly, or probably, burial places in the first instance. It is true that Silbury Hill has been opened and no human interment discovered, but it should be remembered that at the times when the diggings were carried on the skill and experience which are now applied to finding the burial were not forthcoming.

A three mile walk along the high road, parallel with the River Kennet, brought the party to Fyfield. Just before entering the village some large sarsens in the steep roadside were examined. This bank supports a terrace. The opinion has been hazarded that the stones were placed in the bank by prehistoric man. The Director pointed out that these stones are rounded at the edges and not apparently chipped. A little farther on a magnificent, mortarless wall of large sarsens, chipped and squared, was examined. This modern wall was compared with the seemingly older one previously seen. The importance of other items on the programme prevented the members paying much attention to the small Chalk pit east of Fyfield. A thin layer of tabular flint runs right across the section. Specimens of sarsen with rootlet holes and also others containing flint pebbles were obtained from stones which had been brought to the pit.

A few hundred yards farther on the party left the high road and entered the Valley of Stones at Piggle Dean. A plot of a few acres in extent in the bottom of this dry side valley has been bought for the public. Above this plot, however, the members of the excursion witnessed the destruction of the sarsens actually going on, especially on the hillside west of the narrow valley; thus the evidence of the sarsens having once lain on the lower hillsides is being destroyed here, but fortunately exists at other spots. On the Warren, a little to the north, the sarsens are scattered over the ground in the bottom of another dry valley up the slope and on top of the down or hill. Farther along the hill to the north are some ploughed fields (on Hackpen Hill), at 885 ft. O.D. or less, one of which, near "Glory Ann" Barn, is said by the late Rev. A. C. Smith to have been the "fountain head" of the sarsen stones; and, indeed, a glance at the large Ordnance Map would seem to show Mr. Smith to have been right. The stones crowd up to this very spot, and are only (on the map) cut short by the boundaries of the ploughed fields. These fields show red and yellow clay in places, and patches of drift from which the Director has taken Palæoliths, all stained ochreous or brown or greenish (mostly the two latter), together with "Eoliths" or merely edge-trimmed tools, apparently of no greater age. The Palæoliths themselves seem to be of different periods.

Whilst the party was in Piggle Dean the question of the former extent of the sarsens was discussed, and the Director pointed out that the stones lie thick in West Woods, on the other side of the river Kennet.

A Neolithic (Bronze Age, or later Romano-British ?) flake was picked up in Piggle Dean. One of the party pointed out some (marks of) soft patches of stone within the fractured sarsens, as though a subsequent infilling of a little channel in the stone had taken place.

At Down Barn, farther up the dry valley, the party was brought face to face with some very marked terracing which ran in various directions. At the foot of one low terrace was a remarkably regular row of sarsens. A discussion took place as to the origin of these terraces, but on reaching higher ground, whence a more general view of them was obtained, it was agreed by all that they were the work of man.

A beautiful piece of Down was then crossed, the lower and southern continuation of Hackpen Hill. Above on the right, to the north were knolls with bushes and heather, showing the site of Tertiary outliers, etc. To the south, at right angles with Hackpen, lay the great range of southern hills running up to nearly 1,000 ft. O.D. From the top of Martinsell, at 940 ft. the Director had obtained a flaked stone, identified by Mr. Worthington Smith as of Palæolithic age. The country was described as typical Chalk country. Dropping down the low escarpment into Avebury, the excavations dug by the British Association and the remaining stones of the circles were examined. In the former Mr. Gray went down 17 ft. from the present bottom to the original one. He found various levels with pottery, the oldest and lowest being either early Bronze or pure Neolithic, dating Avebury as 1700 B.C. (date of Stonehenge) or earlier. Avebury consisted of a huge trench and ramp outside it, and two double concentric circles of large, unhewn sarsens, which again were both surrounded by an outer circle just within the trench. Many of the stones have been destroyed in quite recent times. One, and probably two avenues of Sarsens led away from the place, one to a small circle near West Kennet.

The party drove up the (here) north and south valley of the Kennet—a mere ditch above Avebury, where it takes a right angle turn—past the Neolithic (probably Bronze and British) site of Windmill Hill. Undulating country lies between the river and Hackpen Hill, also to the west of the former. Here the Director has found Eoliths and a few flaked stones (of Palæolithic nature) at levels from 520 ft. to 600 ft.

On arriving at Winterbourne Bassett the Director gave a short account of his large collection of flint implements, etc., drawing attention especially to

	ft.
1. Eoliths and Palæoliths (the latter as old as the former) from Hatfield, Herts, Lea Valley . . . about	220
2. Ditto, from Hackpen Hill	875
3. Ditto from Winterbourne Bassett	550 to 600

4. Palæoliths from Knowle Farm Pit, especially one lot dug out of one large hole, some found *in situ* by himself.
5. Palæoliths and Eoliths side by side, and exactly resembling each other in many cases and in different types, as regards edge-trimming and general outline.

Mr. E. P. Ridley, in proposing a vote of thanks to the Director, noted that he (the Director) avoided the word Eolithic, and substituted "early Palæolithic."

The party took tea in the village school, and glanced at a fallen stone circle in Winterbourne parish, and at the Lower Chalk cutting on Clyffe Hill *en route* for Wootton Bassett station, whence they returned to London by the 8.2 train.

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VISIT TO THE PALÆONTOLOGICAL EXHIBIT IN THE SCIENCE HALL, FRANCO-BRITISH EXHIBITION.

MONDAY, JULY 6TH, 1908.

Director: F. A. BATHER, M.A., D.Sc.

(*Report by* THE DIRECTOR.)

AT six p.m. more than fifty members met in a temporary enclosure round the division of Geology in the Science Hall. After welcoming them, and expressing his thanks to the exhibitors, some of whom had kindly come to answer questions relating to their own portions of the exhibit, Dr. Bather passed through the Exhibit illustrating Modern Methods of Palæontological Research from beginning to end. Here it is only possible to give the briefest abstract of his remarks, but those interested are referred to the list of books and papers at the end of this report (pp 546, 547).

This is not an exhibit of fossils, even of rare fossils, or of specimens with a purely scientific interest. It is intended to show modern methods employed in the study of fossils, especially those followed in this country. It is arranged under four headings: Collecting, Preparation and Preservation, Study, and Presentation of Results (No. 15 in list at p. 546).

A. THE COLLECTION OF FOSSILS.—We do not exhibit the ordinary set of hammers and chisels, or show the casual way in which people too often collected twenty years ago. We first illustrate Zonal Collecting in its various aspects, and naturally begin with a set of Graptolites shown by Professor Lapworth. Wide distribution in space and brief distribution in time combine to make the successive species of graptolites excellent zonal guides in the older rocks, and thus enable experts to work out the original stratification in highly disturbed areas (17). These specimens show that a precisely similar succession obtains in the Tarannon rocks of the South of Scotland and of the Lake District.

Unlike the alternating series of shales and limestones of the Ordovician and Silurian rocks, the Carboniferous Limestone forms a thick, fairly homogeneous mass over a large extent of country. The problem of splitting this into zones has recently been solved by Dr. A. Vaughan (28), who here exhibits thin sections of various species and genera of Corals, illustrating the minute changes of form found in these and other animals as they pass through successive horizons. The specimens are also selected to indicate results of broader evolutionary importance obtained by zonal collecting in the Avonian rocks, as explained in the Guide (15).

The Ammonites, like the graptolites, present a rapid succession of widely distributed species, and have, therefore, long been used to distinguish the larger zones of Jurassic rocks. The more minute division now possible, owing to detailed work on the genera and species, is demonstrated by our leading British authority, Mr. S. S. Buckman, who shows Ammonites characterising the zones of the Inferior Oolite (12 and 11, p. ccv). Among the many laws of evolution exemplified by Ammonites is the fundamental one that an animal in its individual growth passes, it may be rapidly and imperfectly, through the stages that the race passed through before it. Thus these successive species of *Parkinsonia* present broadening whorls and a narrowing umbilicus, changes also seen in the growth of this single shell of *Parkinsonia dorsetensis* (11, p. cxcviii).

The next exhibit explains how the evolution of a single line of descendants has been used to work out the zones of a mass of rock even more homogeneous than the Mountain Limestone. Study of numerous fossil sea-urchins of the genus *Micraster*, carefully collected foot by foot from successive layers of the Chalk, revealed to our eminent member, Dr. A. W. Rowe, the minute changes that invariably accompany the upward passage of this genus through the rock (22). Among other members of this Association who have put this discovery to practical use are

Messrs. T. H. Withers and C. P. Chatwin, to whom I am particularly indebted for this beautiful exhibit. It will be noticed that the changes are very gradual, and, though certain structures characterise certain zones, still structures of intermediate form are found at intervening levels; at no level can a definite line be drawn. The complete series of evolving forms obtainable from this gradually accumulated rock convinces me that species were transmuted gradually and not by a series of jumps.

Preceding exhibits illustrate the collection of selected species from beds of rocks deposited in successive periods of time; the next one represents an attempt to collect all the species living together at a single period. These specimens have been collected by Mr. Lewis Abbott from the shell-bed at Swanscombe, Kent (3), from excavations at the Admiralty buildings (1), and from fissures in the Kentish Rag at Ightham (2, 3, and 20), and the period is that when man first appeared in that part of the country. Though a mere sample from Mr. Abbott's large collection, and omitting the larger fossils, this exhibit gives a good idea of the fauna of S.E. England at that time, and enables us to appreciate the change in the character of the fauna between that remote period and the present day. The change is of three distinct kinds—a migration northward in the same island; a killing out within these isles of certain species which survive on the continent; and the total extinction of other species.

Mr. Abbott also shows the apparatus by which he obtains his specimens. The methods chiefly used are: (*a*) sifting through sieves of varying mesh; (*b*) separation of small light fossils by attraction to electrified ebonite or amber; (*c*) separation of light fossils from loose material stirred up in water, by slow removal of the water through capillary attraction.

The collection of fossils from a formation of similar loose composition is further exemplified in Mr. F. H. Butler's exhibit of the tools used by Searles V. Wood (1798-1880) to pick out shells from the Crag, when forming the collections now in the British Museum and the Ipswich Museum (10).

B. THE PREPARATION AND PRESERVATION OF FOSSILS.—When fossils have been collected, the next step is to clean them, and this is a step many people seem inclined to omit. They seem to think that experts, or even untrained geologists, can name and study specimens while all details of structure and ornament are still obscured by matrix. That this has not been the case in the past is proved by the large number of erroneous determinations and the controversies to which they have given rise. Still less is it the case to-day, when the determination of specimens depends on exceedingly minute points. As one who is constantly being asked to name such imperfectly cleaned material, I would repeat with emphasis the appeal already made to you by Dr. Arthur Smith Woodward in his Presidential

Address (30). Much may be done by the simplest tools and methods, such as are here illustrated. But often the more elaborate methods here displayed must be employed. None of these methods, however, is beyond the capacity of even an amateur collector, if only he has enthusiasm and perseverance. The two golden maxims are "go slowly" and "gently does it."

[The Director here demonstrated the series of exhibits that elucidate cleaning by physical, mechanical, and chemical methods. Since any adequate account of these would be too long for this Report, he has published a special paper on the subject in the *Museums Journal* (10).]

Many fossils are so fragile, or in such crumbly material, that they must be hardened before being handled, while others need special treatment if they are to be preserved in a cabinet or museum. [For a full account of the methods illustrated, and the hardening solutions exhibited, reference should be made to the paper just mentioned (10).]

C. THE STUDY OF FOSSILS.—The specimens having been cleaned, the next thing is to study them. Some think that all they have to do is to name them, or to get them named. This is not the end of palæontology, but its beginning. The object of names is merely to enable us to explain to others in a rapid manner what objects we are talking about, and, while they must therefore be correct, still if they are taken as the end of study they serve merely to hinder and obscure the knowledge of facts.

Descriptions of animals and plants, both recent and fossil, often contain such words as "small," "large," "thick," "thin," "feebly developed." These expressions, like the classical phrase, "big as a lump of chalk," have no meaning except to their user. Science is measurement, and nowadays this statement is as applicable to the biological sciences as it has long been to the physical ones. Measurements must be accurate. Use the metric system, but do not stick at millimetres; measure to tenths of a millimetre or less. Use accurate instruments such as these sliding callipers with pointed ends and a vernier scale, made by G. Boley, Paris. Measure not only the type-specimen but thousands of specimens, if they can be obtained, and construct graphic curves (13). In this, as in all parts of your description, remember that what is detailed enough for one generation is of small value to the next. Be in advance of your time.

The structure of fossils can often be ascertained only by cutting sections, but in preparing these as objects for the microscope a large part of the fossil is necessarily destroyed, and it is impossible to obtain a complete series like those used by anatomists. The difficulty is evaded by grinding down the surface and making drawings with the camera lucida at intervals: such are the sections through the plates of a Cystid (8). More precise work is rendered possible by the machine constructed for Professor Sollas from the drawings of Mr. Jervis-Smith by Mr. R. W. Munro of King's Cross Road (26). Photographs of the ground surface are taken at known intervals and enlarged. These outlines are then traced on waxed sheets of a proportional thickness and cut out. The sheets are then built up into an enlarged model of the original fossil, such as the reproduction of *Monograptus priodon* by Mr. Norris, or these of *Lapworthura* and *Palæospondylus* (27) by Professor and Miss Sollas. Alongside is a model of *Palæospondylus* by Dr. Traquair, which may be less exact, but is certainly more intelligible to the non-expert than is the one produced by purely mechanical means.

The difficulties to be contended with in reconstructing fossils are manifest in this series of *Pterichthys*: first, a facsimile of the best specimen in the British Museum; next, a paper model by Hugh Miller, now in the British Museum (photograph by Mr. H. Herring); lastly, reconstructions made first for the British Museum and afterwards improved by Dr. Traquair for the Royal Scottish Museum. Three-quarters of a century has it taken to reproduce the outer form of this creature, whose inner anatomy is still a subject of controversy.

These beautiful models of *Eurypterus*, made by Mrs. Delta Blackman for the British Museum, are perhaps the most accurate reconstructions of an extinct animal that have yet been made, the more remarkable since the species lived so long ago as the Silurian Period (7).

Passing over this reconstruction of the Carboniferous Arthropod *Prestwichia* (melius *Euproöps*) made by Mr. F. Bowcher, the designer of the Geological Society's Prestwich Medal, and Mr. Crick's most instructive model of the Silurian Cephalopod *Ascoceras*, we come to plaster reconstructions of the skulls of three mammals, *Moeritherium*, *Palæomastodon*, and *Prozeuglodon*, based by Mr. F. Barlow on the incomplete specimens collected by Dr. Andrews in the Fayûm and drawn in these plates (6). Sketches by Miss A. B. Woodward represent the animals as they may have lived. The skull of a giant bird, *Phororhachos*, was modelled by Mr. Caleb Barlow, whose recent death we of the Geological Department so greatly mourn (5).

When fossils are preserved only as impressions or external moulds, it is necessary to take a squeeze in wax or some plastic substance. We are much indebted to Mr. E. T. Newton for a series explaining the way in which he studied the reptilian bones that have left their traces in the Triassic sandstone of Elgin (19). The cavities are broken open, the surface wetted, and gutta-percha softened in hot water pressed on the imprints. The gutta-percha is laid on bit by bit, each piece overlapping its predecessor. The pieces are then removed and built up into the semblance of the original fossil, their edges being joined by melting with a hot knife. From the model thus obtained a plaster cast may be taken in the ordinary way. Thus was made this wonderful reproduction of the skull of *Elginia mirabilis*.

Every group of fossils requires special methods in its study, according either to the nature of the material, or to the characters that it is necessary to elucidate. In so far as our study progresses beyond merely superficial and elementary description, the more elaborate and technical are our methods and terminology, so that every pioneer is abused by those who will not be at the pains to follow his advance step by step. Although Ammonites are such common fossils, their modern study cannot be comprehended by the light of nature alone, Mr. Buckman has therefore arranged a series in explanation of the various features utilised in their description (11). This may serve as a sample of the kind of work now being done on all groups of fossil animals.

The botanists have long since reduced the descriptive branch of their science to circumstantial rule expressed in elaborate terminology. Here we have preferred to show some examples of the recent striking advances in vegetable morphology obtained by studying the plant nodules or coal-balls of the British Coal Measures (23). The whole process of obtaining, cleaning, and cutting these remains is here explained, and a fine series of the large transparent sections made by Mr. James Lomax is exhibited. The results obtained by Messrs. Oliver, Scott, Weiss, and others are illustrated by the photographs and models, and for some of the latter we have to thank Mr. Smedley.

C. PRESENTATION OF RESULTS.—Having collected our fossils, having cleaned them, having studied them, and having got to know as much about them as our brains and time will allow us, we have next to write our results. But before doing that it is very important to know what other people have said on the subject. No one wants to say over again what has been said before. So much has been published that it is necessary to take advantage of those valuable aids to study known as bibliographies and indices, of which we have a few here. Let me impress upon you that you can find out what has been said if you will only study these (14, 24, 25).

Having written your paper—I have not exemplified here the many faults into which people may fall when they write a paper (4)—the next thing is to illustrate it. Now the illustration of Graptolites presents considerable difficulties, and those of you who have seen the great Monograph of British Graptolites, being published by the Palæontographical Society, have no doubt observed how well these difficulties have been overcome. [The process is fully described on pages 2 and 3 of that work (18).] Here are the microscope used, the enlarged drawings, and the reductions to natural size as printed in the plates. In this connection, let me pass on to you the advice constantly given by my old teacher, Professor Moseley: "Make your drawings large. Then you will not be able to fudge your work. A drawing cannot be too large, it can always be photographed down to a size convenient for publication."

For examples of the photography of fossils we have naturally had recourse to Mr. J. W. Tutcher, of Bristol, with whose work you are familiar. He shows also a photograph of the apparatus used by him. The specimen is laid flat, and the camera placed above it, thus the difficulty of fixing the fossil is avoided, and the lighting can easily be arranged. It is important that all figures on a plate should be lit from the same quarter, the top left-hand is that usually adopted. It is Mr. Tutcher's custom, as also that of Mr. and Mrs. Clement Reid (21), as here shown, to obtain a white background by placing the specimen on a clear glass and reflecting white light from a more distant expanse of white. This is an unnatural arrangement, and the glare of the white background renders it less easy for the eye to take in the detail of the figures. The dark background used in this plate (9), is to my eyes far more pleasing. This plate also illustrates the process of retouching, often necessary when the fossil presents peculiar difficulties which the camera is incompetent to overcome. Photographs of the natural size have been greatly enlarged, retouched, and then reduced in the course of preparing the collotype plate in question.

The methods of illustration should be studied by all who write scientific papers, for they would thereby save themselves and their editors much trouble and expense. This series, incomplete though it is, will show what a large choice of methods there is, from the expensive photogravure down to the cheap zincotype. You will also note how one specimen or diagram demands one kind of technique while another kind is better adapted for a different object (16, 29).

The actual publication of palæontological work is represented by the society that exists for that sole purpose—the Palæontographical Society. Here is its last volume, and also a selection of its plates during the last sixty years, exemplifying the work of the leading artists—Sowerby, Bone, Erxleben, Searle, and others (nor let us forget Phœbus Apollo), and the various methods employed.

On the motion of Dr. Salter, seconded by Mr. G. W. Young, the members present passed a vote of thanks to the Director, who, in acknowledging it, said he had not wished to frighten them by showing the extent and difficulty of palæontological study, but rather to suggest that in one or other of its departments it presented a field to any and every member of the Geologists' Association.

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* Dr. Bather will be pleased to give a copy of Paper No. 10 to any Member present at the demonstration who will write for it to him at the Natural History Museum, London, S.W.

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EXCURSION TO CULHAM AND ABINGDON.

SATURDAY, JULY 11TH, 1908.

Director: LLEWELLYN TREACHER, F.G.S.

Excursion Secretary: W. P. D. STEBBING.

(*Report by* THE DIRECTOR.)

A SMALL party started from Culham Station at 12 o'clock, and proceeded westward along the Abingdon Road. The first halt was made near Culham College, where, on the opposite side of the road, a small excavation in a field showed 8 ft. of well stratified gravel consisting mainly of small rolled fragments of Jurassic Limestone, intermingled with which were a few large pebbles of red quartzite, smaller ones of white quartz, and other contributions from the northern drift, together with some subangular flints and many derived fossils, chiefly *Gryphæa dilatata* and broken Ammonites. Some bones of ox and deer from the base of the gravel were exhibited. There appears to be an extensive spread of this gravel hereabouts at levels varying from 30 to 50 ft. above the Thames.

A little farther along the road a turning to the left was taken down a lane towards the river at Culham Lock, and the small sand pit was reached which was visited by the Association five years ago and described in the PROCEEDINGS by Mr. H. J. Osborne White, the Director on that occasion. It exposes about 10 ft. of coarse, current-bedded sands, or small pebbles, of Lower Greensand age, generally in a loose condition, but in places hardened into large irregular masses by carbonate of lime, probably the result of the decomposition of calcareous fossil remains. Recognisable fossils are very scarce, none being seen either now or on the previous visit, although the *Survey* record the finding of three species in the interval, the most important of which is *Exogyra sinuata.**

A short walk to the river bank and along the tow-path down stream brought the party to the well-known clay pit in Culham brickyard, which has been noticed by several writers and described by John Phillips in 1860 and by Mr. Osborne White in 1903. The variations in the descriptions of this section by different observers many years apart may be accounted for by the fact that as the face of the excavation is cut back towards the east new exposures of the strata come into view, the northern ends of the old ones being covered up under the spoil bank.

The lower half consists of a dark sandy clay containing many fossils belonging to the fauna characteristic of the Hartwell Clay, a deposit marking both lithologically and palæontologically the transition from the Kimeridge Clay to the Portland Sands. Besides the forms previously recorded from this bed there may be commonly found *Arca longipunctata* and fragments of an Ammonite near to *Am. boidini*, the latter of which has been recorded by J. F. Blake from the Portland Beds of Swindon.

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* See also C. G. E. Dawkins, *Geol. Mag.*, 1906, p. 24.

This clay passes upwards into a band of hard sandy limestone which forms a conspicuous feature in the section. Although as at present exposed it is only a few inches in thickness it is probably the representative of the "9 ft. of fine-grained greensand" seen by Phillips at the western end of the pit fifty years ago. Notwithstanding the opinion expressed on the 1903 excursion that Phillips had mistaken some material slipped from the higher parts of the pit for this sand in place, the Director, after due consideration, sees no reason to doubt the description given by that writer. In confirmation of this view the President remarked that he had visited the section twenty years ago, and remembered having then seen some feet of sand in about the position of the limestone band. The variations in thickness of the stratum in question may be owing either to irregularities in its original deposition, or, far more likely, to the great denudation which preceded the laying down of the overlying Gault, and at this spot removed rocks of Portland, Purbeck, Wealden, and Lower Greensand ages, all of which are represented in the neighbourhood, as it is hardly probable that with so great a thickness of strata missing the newer deposit should rest quite conformably on the underlying beds. The remark of Phillips that the sandy deposit seen by him marked the incoming of Portland conditions, although the fossils of the sands were identical with those of the underlying clays, will apply equally well to this limestone band.

Next above it, and resting on its slightly uneven hard nodular surface, comes a tough conglomerate a foot or so in thickness, consisting mainly of small pebbles, like those seen in the sand pit above mentioned, held together by clay similar to that coming on above. Intermixed with these are many black nodules and casts of fossils probably derived from some of the Portland beds of the neighbourhood. In addition, this bed contains an abundant contemporaneous fauna, among which may be mentioned *Lima globosa*, a common Selbornian fossil, and *Ammonites beudanti*, some specimens of which are of a very large size. Mr. Osborne White has also recently found, among many other forms, a specimen of *Ammonites mammillatus*. The presence of these fossils seems to prove that the pebbly bed represents the *Ammonites mammillatus*-zone, and further that this zone constitutes the true basement bed of the Gault rather than the topmost bed of the Lower Greensand.

All the clay seen above the conglomerate is ordinary Lower

Gault belonging to the *Ammonites interruptus*-zone, in which the zonal fossil is abundant.

On leaving Culham clay pit, the party crossed the Thames by the toll bridge and continued the journey through Sutton Courtney to the eastern end of the village of Drayton, where another stop was made to examine some gravel pits by the side of a lane leading south from the main road. The land surface here is about 30 ft. above the present river level, and the gravel belongs to the second and most widely spread of the terraces of the Upper Thames Valley. In these pits it is much current-bedded, and its constituents are practically the same as those of the gravel near Culham College, but in addition, many large angular pieces of Malmstone were noticed, containing casts of the characteristic fossil *Grammatodon carinatus*, which show that although it is essentially a Thames gravel, it lies well within the influence of the Ginge Brook, a stream which drains the Selbornian country to the south-west. A tufaceous deposit encrusts many of the stones, and in places holds them together in a sort of conglomerate. As elsewhere in this terrace the gravel contains many contemporaneous mammalian bones, a collection of which from these pits has been made by Mr. Eli Caudwell, of Blewbury, who was unfortunately prevented by illness from attending the excursion.

Passing through Drayton, a brief visit was paid to the brick-yard at the western end of the village. The pit here in Kimeridge Clay was found to be so completely filled with water that nothing could be done beyond looking over the heaps of clay, which yielded but few fossils. The following have been collected here by Mr. John West, of Abingdon, and Mr. R. N. Carew Hunt, of Bradfield College: *Ichthyosaurus*, *Plesiosaurus*, *Ostrea deltoidea*, *Astarte ovata*, *Cardium striatulum*, *Trigonia* (cast), and fragments of Ammonites. As the party was leaving the yard a workman appeared with a large basket containing a great number of specimens of *Thracia depressa.*

Although the next section lies scarcely three miles in a direct line from Drayton, it was found necessary to take a long and circuitous drive of nearly double that distance to reach it. The route lay past the western suburbs of Abingdon, through Marcham to "Noah's Ark," the name of an inn on the main road from Wantage to Oxford. North-west of the inn the uneven surface of the fields gave evidence of old quarrying operations of considerable extent, the limestone of the Corallian formation having formerly been worked here for lime burning. Noah's Ark limekiln is a thing of the past, and the only pit now open is a small one about 10 ft. deep near the road. At the bottom about 3 ft. of Lower Calcareous Grit was seen consisting of the usual sand with doggers. Above this comes 18 in. of the hard, shelly flagstone of the Coralline Oolite, which is here less fossiliferous and consequently less developed than usual. It is overlaid by 4 ft. of fine to coarse rubbly oolite and brash containing many specimens of *Echinobrissus scutatus* and a few of *Myacites*. The topmost bed is 1 ft. of Coral Rag almost entirely made up of broken corals, chiefly *Thecosmilia annularis*, on one of which was noticed a zoarium of *Stomatopora*. Neither tests nor spines of *Cidaris florigemma* were seen, though it is so characteristic of this bed in Berkshire.

In one part of the section the soil and subsoil to a depth of 3 ft. appeared to have been removed, and the excavation filled up with burnt earth and wood ashes, amongst which were noticed pieces of ancient pottery, of bones, presumably human, and of Niedermendig lava. Mr. Neville Aldworth, the owner of the quarry, informs the writer that over some thirty acres of ground to the north of it he has dug up a great number of lead and stone coffins containing bones and jewels, also urns full of ashes. The late Dr. Rolleston of Oxford put the date of this buriai place in the transition period between Roman and Saxon times.

Leaving the inn by the north road, the drive was continued through the hamlet of Frilford to Frilford Heath, which is now enclosed. The soil is very light and sandy, the denudation of the upper Corallian beds having left the Lower Calcareous Grit exposed at the surface. A quarry on the east side of the road showed about 10 ft. of loose, current-bedded, sands with masses of hard stone which take two distinct forms, one, as a rule in the lower part of the section, being of the round or oval dogger type, the other that of evenly-bedded flagstones which break with a rectangular fracture. The only fossils noticed were a few specimens of *Exogyra nana* from the sands and one of *Am. cordatus* from the flagstones.

Turning eastward again towards Abingdon, the entrance to the more westerly of the Marcham Field quarries was soon reached. The quarry itself lies some distance off the main road, near Sheepstead Farm. It has been often described, and on two previous occasions been visited by the Association. The section shows all the Upper Corallian Beds, from the Coral Rag downwards, and also some thickness of the Lower Calcareous Grit. The strata dip towards the south-east, but owing to the general slope of the ground being greater in the same direction lower beds come to the surface at that end of the quarry. At the northern end the Coral Rag is 6 ft. thick, and has its upper half consolidated into a compact rock, below which it consists almost entirely of *Thecosmilia annularis* in a very broken condition. All the underlying beds as described by Mr. H. B. Woodward were found to be well exposed, and the opportunity was taken advantage of for collecting the numerous species of fossils. Besides examples of most of those already recorded the following were found: Small fish teeth, common in the sands of the Lower

Calcareous Grit, *Neritopsis decussata*, *Avicula expansa*, *Waldheimia margarita*, *Berenicea*, and *Astropecten rectus*. Among the constituents of the hard shell beds were noticed pieces of a substance resembling the "Beef" of the Purbeck Beds. They appear to have been derived from some older beds, or at least rearranged, as many were covered with small oysters, Serpulæ and Bryozoa. A large heap of blocks of the *Natica* Bed came in for a good deal of attention, but the excessive hardness of the stone prevented much execution being done on the many fossils contained therein. Its being composed mainly of internal casts of shells surrounded by hollows from which the shell substance has been dissolved gives this stone a peculiar honey-combed appearance, and Mr. Walter Gall, of Marcham, the owner of the quarry, informs the writer that it is in consequence in great demand for grottoes and rustic rockwork, being sent to long distances for the purpose.

Having spent nearly an hour here, the members, finding that time did not permit of a visit to Mr. Long's quarry in the adjoining field, departed direct for Abingdon, where on their arrival they were hospitably entertained by Mrs. H. S. Reynolds at her residence, "The Gables." After tea, under the guidance of their hostess, they made a rapid inspection of the old almshouses and some other antiquities of the town, leaving Abingdon by the 6.40 train for London.

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GEOLOGISTS' ASSOCIATION.

FOUNDED 1858.

THE OBJECT of the Association is to facilitate the study of Geology and its allied Sciences.

Members are elected on a Certificate of Recommendation, signed by two or more members, one of whom must have personal knowledge of the Candidate. The certificate is read at a monthly meeting, and the Candidate submitted for election at the succeeding Meeting.

Members pay an Admission Fee of 10s.; and an Annual Subscription of 10s., or a Composition Fee for the latter of £7 10s.

LADIES AND GENTLEMEN are eligible for election.

MEETINGS are held at University College, Gower Street, W.C., on the first Friday in each month from November to July inclusive. Two visitors may be introduced by each Member. The chair is taken at 8 p.m. (7.30 p.m. at the Annual Meeting).

FIELD EXCURSIONS and Visits to MUSEUMS and other places of Geological interest are made at various dates, principally between March and August.

The LIBRARY of the Association has been incorporated with the Science Library of University College. Members have the privilege of consulting the combined Libraries daily, and also of borrowing books under certain conditions.

THE PROCEEDINGS AND MONTHLY CIRCULARS are forwarded post free to all Members whose addresses are known, and who are not in arrear with their subscriptions.

Forms of proposal for Membership, and any further information, may be obtained by application to the Secretary,

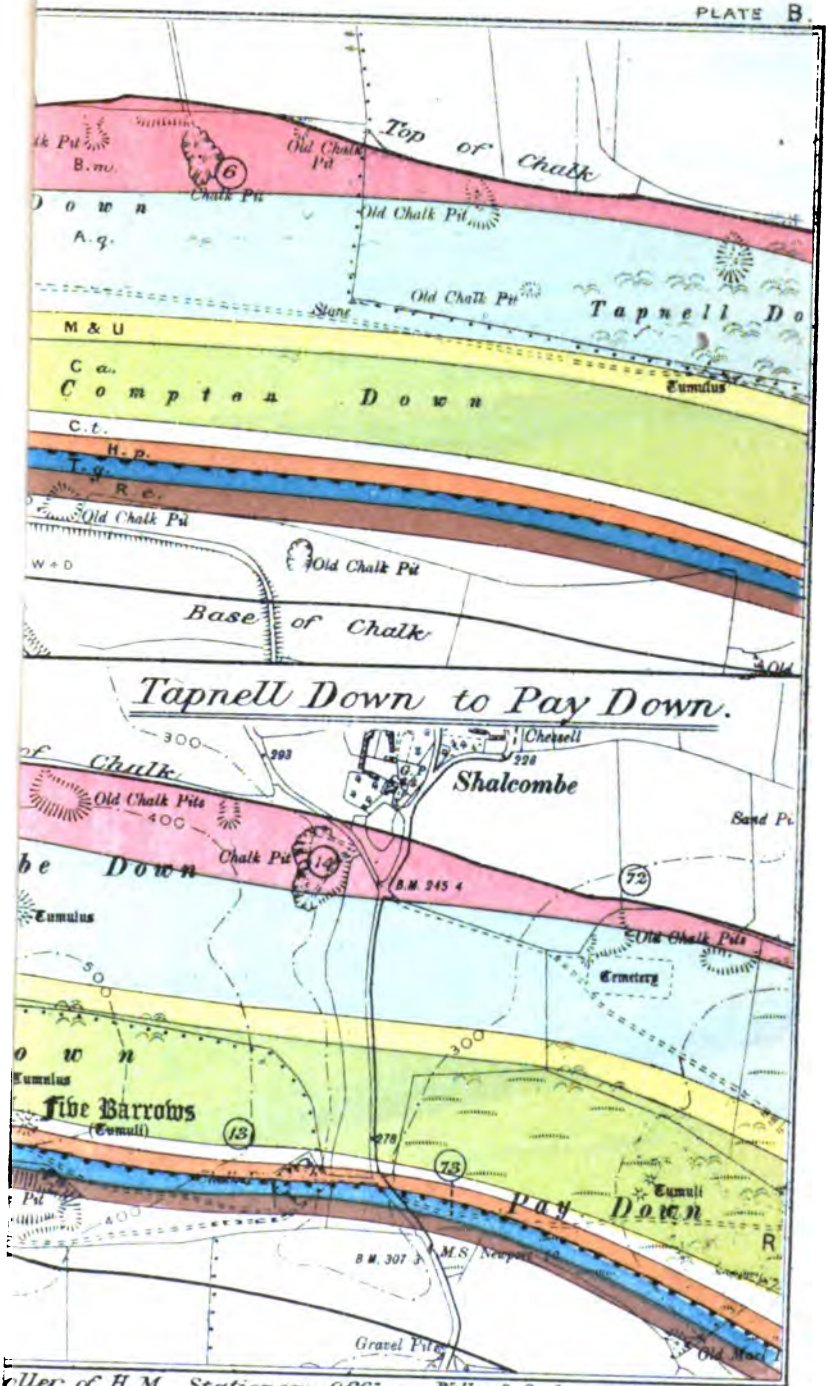
G. W. YOUNG, F.G.S.,
34, Glenthorne Road,
Hammersmith, W.

PROPOSED NEW VOLUME.

To mark the completion of the fiftieth year of the existence of the Association in November next, it is proposed to issue a Volume dealing with the Geology of the Districts of England and Wales visited by the Association since its foundation. The volume will be on somewhat different lines to the "Record of Excursions" published in 1891. It will consist of a series of Articles by competent authorities on the various localities visited, who will deal with the geology of their district from the standpoint of our knowledge at the present day. It will be edited by Messrs. H. W. Monckton and R. S. Herries, and will be uniform in type and size with the PROCEEDINGS.

The price, to Members of the Association who *subscribe in advance*, is 8s. 6d., or *post free* 9s. Remittances should be sent to Mr. G. W. Young, 34, Glenthorne Road, Hammersmith, W.

PLATE B.



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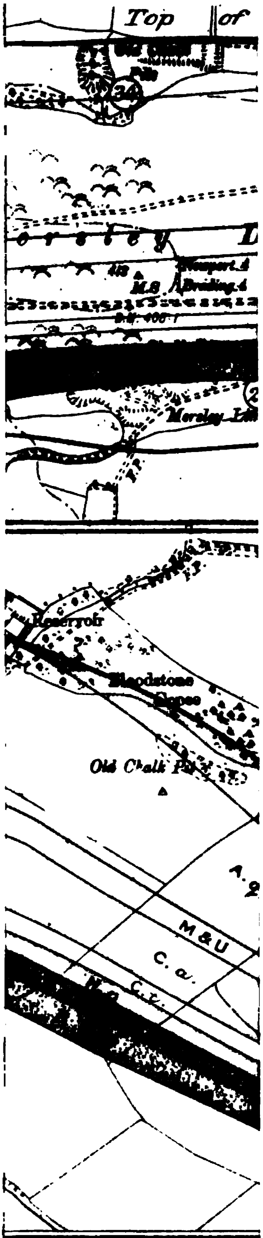

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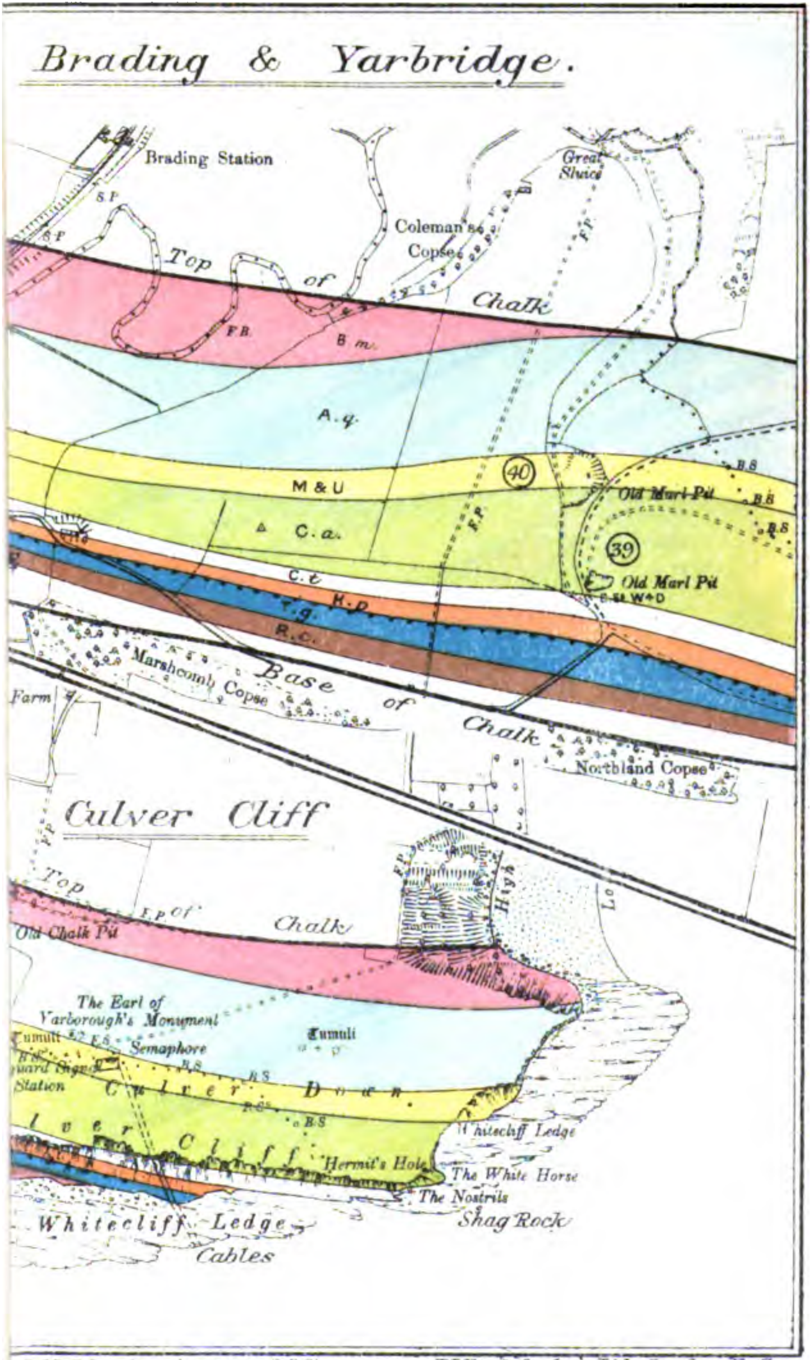
PLATE F.



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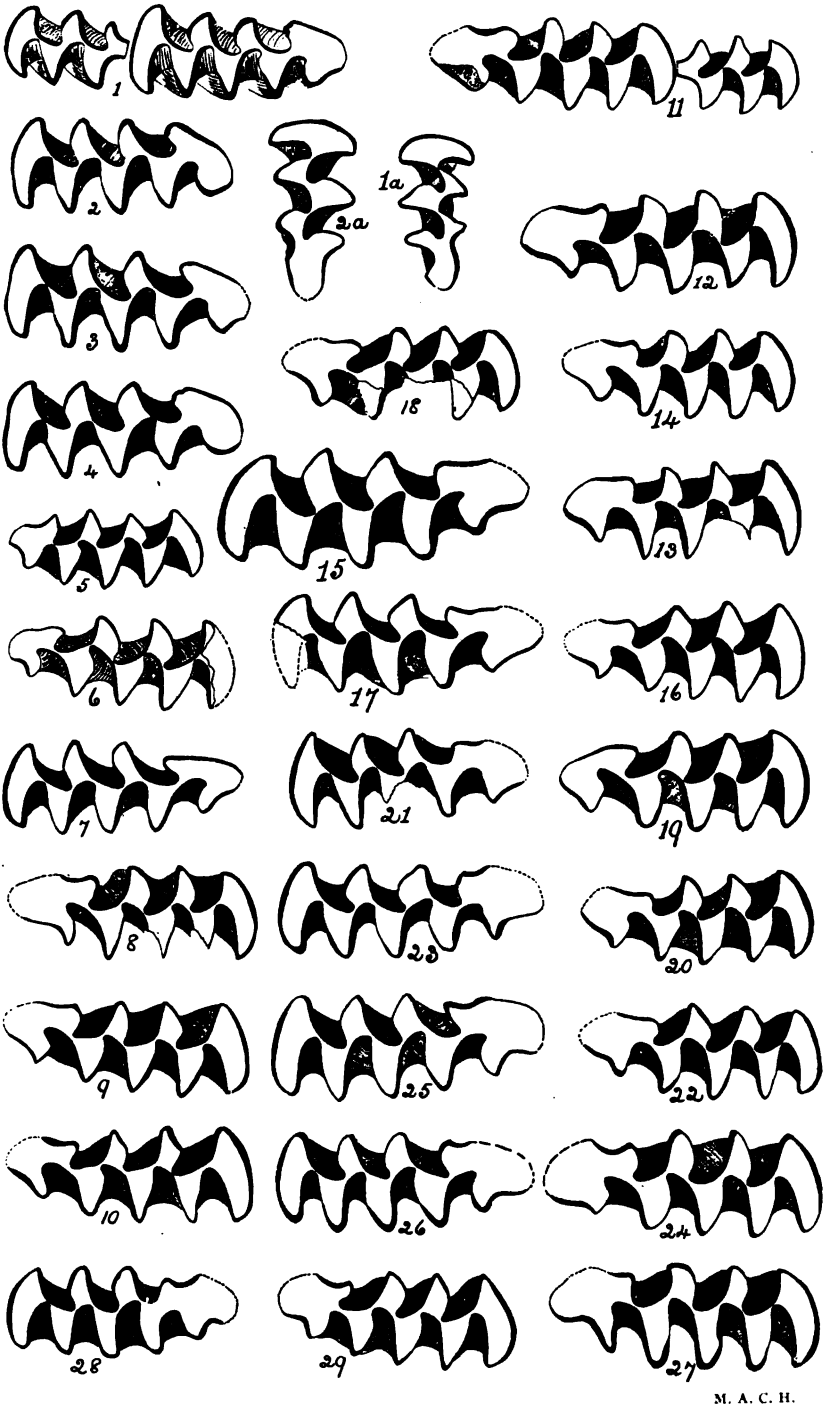
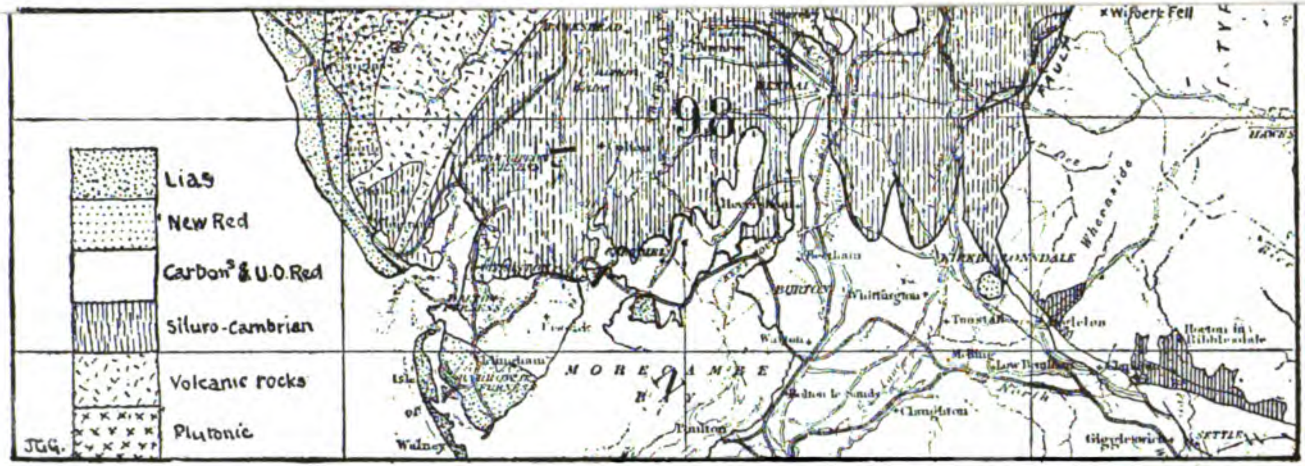


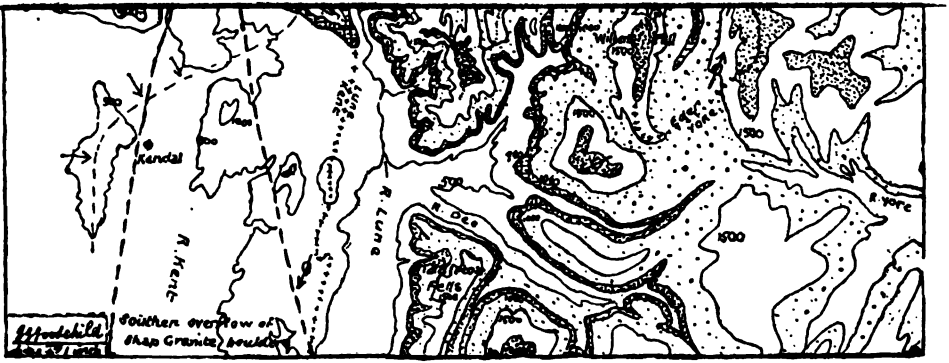
M. A. C. H.

MOLAR TEETH OF *MICROTUS NIVALIS*, ETC.



GEOLOGICAL MAP OF CUMBERLAND AND WESTMORELAND.—J. G. GOODCHILD.

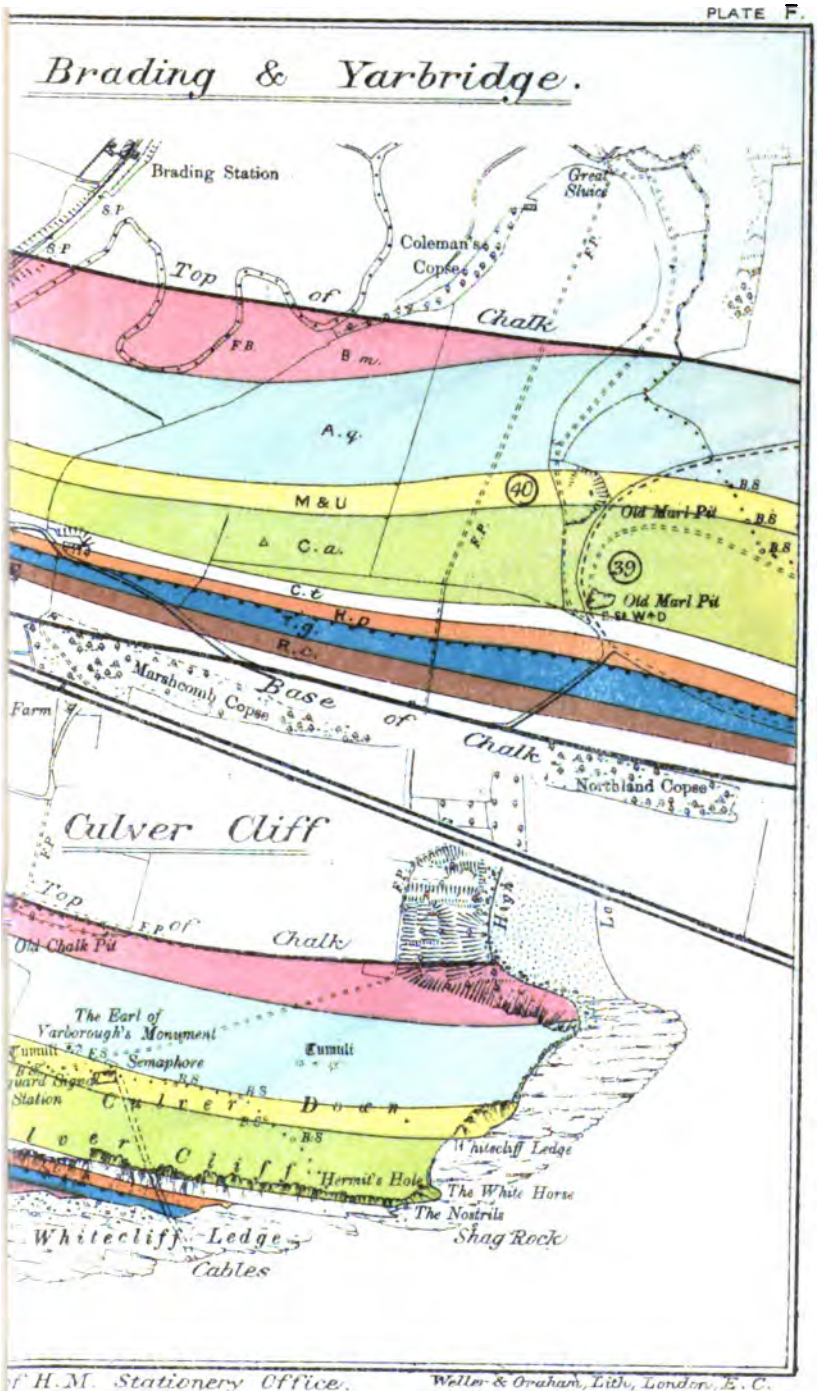
To face page 136.



CONTOURED MAP TO ILLUSTRATE THE GLACIATION OF EDENSIDE.—J. G. GOODCHILD.

To face page 148.

PLATE F.



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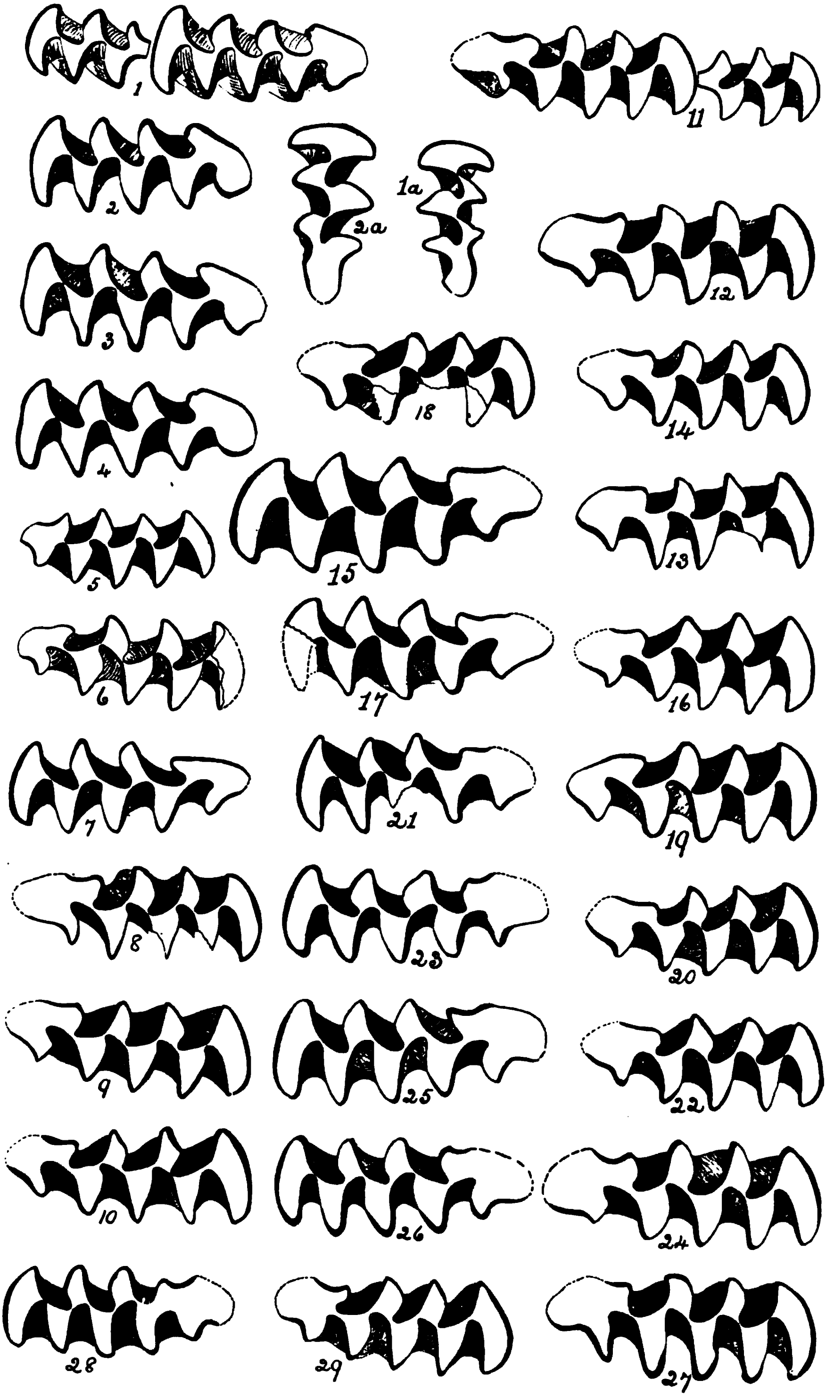
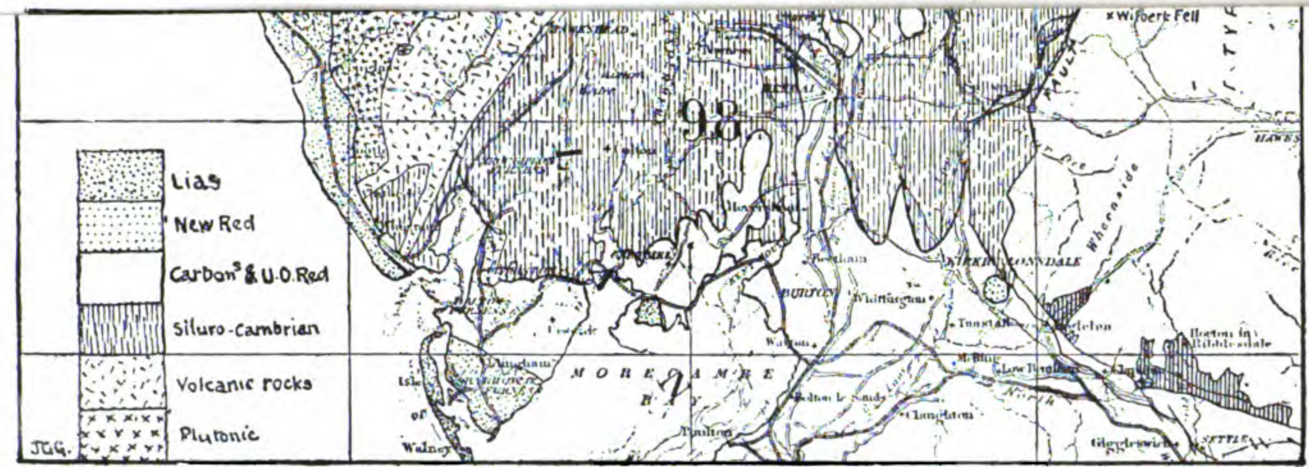
Survey.



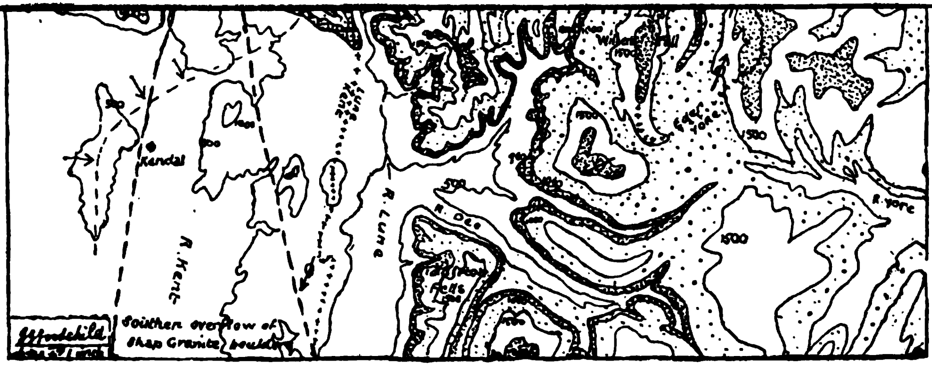
M. A. C. H.

MOLAR TEETH OF *MICROTUS NIVALIS*, ETC.



GEOLOGICAL MAP OF CUMBERLAND AND WESTMORELAND.—J. G. GOODCHILD.

To face page 136.



CONTOURED MAP TO ILLUSTRATE THE GLACIATION OF EDENSIDE.—J. G. GOODCHILD.

To face page 148.

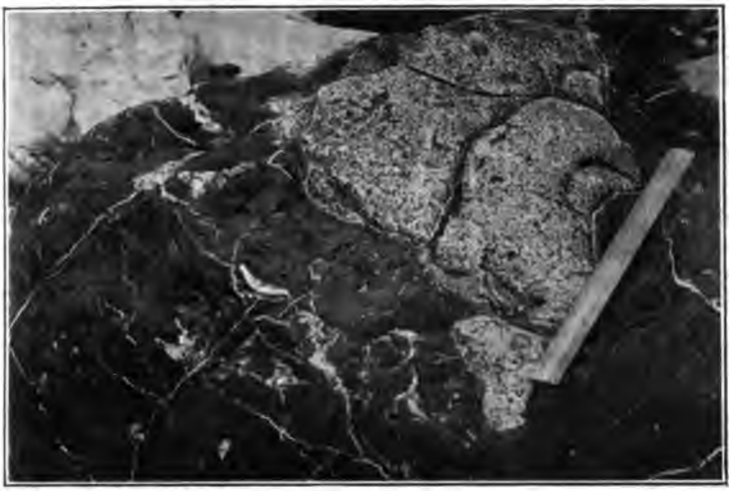


FIG. 1.—LIMESTONE MASS IN BASALT, SPRING COVE.

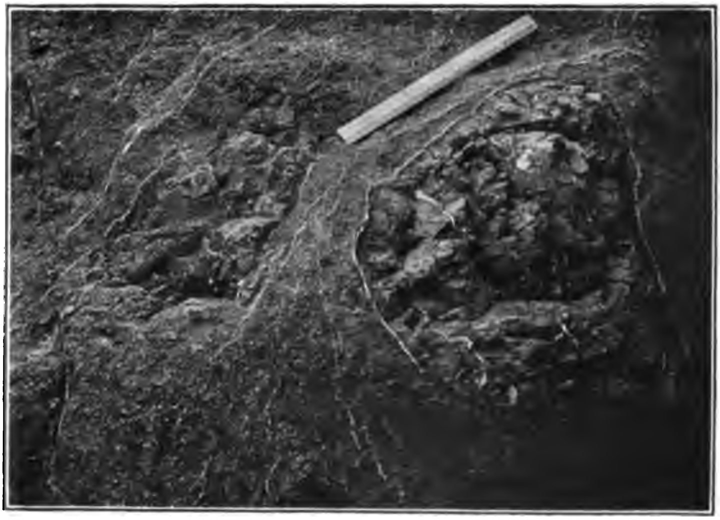
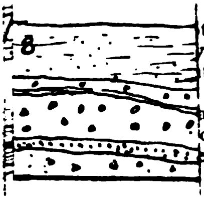


FIG. 2.—SPHEROIDS OF BASALT IN TUFF, SPRING COVE.

Photos by S. H. Reynolds.

F FIG. 1.

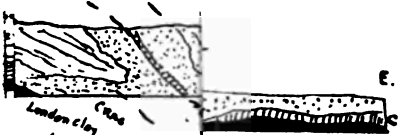
ng Beds—very fine grained.



tone.
y oval-shaped.
torted. Boulder Clay wash

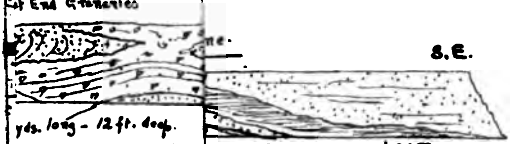
rt and containing streaks of
c.
d from 6 by gravel-chalky

4. _ Hadleigh Rd. Cut

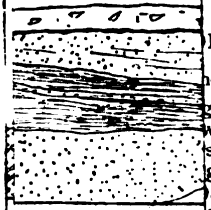


(16yds × 6 ft.) Boulder Clay
k.·x). Scale 2"=1ch.

Fig. 8
mford Rd. (Top).
t End Cemeteries



yds. long - 12 ft. deep.
Clay over-riding Middle . 5ft. deep.
ashed Sands included)



N OF SECTIONS.

e following features :
g 7 B, Fig 1), *e.g.*, where hard
with.
s. 2, 3, 4, 5).
g. 13, Fig. 1).
).
ents of Water (Fig 14, 15, Fig. 1).
th B.C.).
on of Ice.

very chalky - large bl
nd.

ht coloured at bas

ER (1900—19

To face page 192.

PLATE VI.

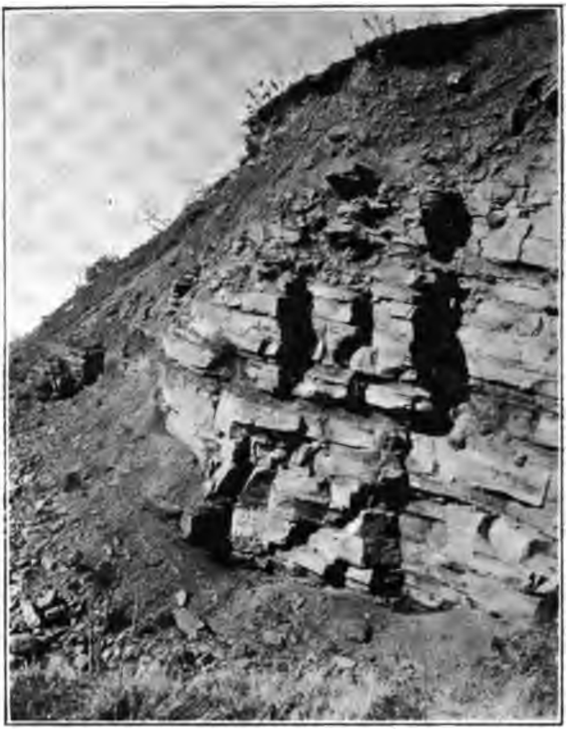


FIG. 1.—DRIFT ON ST. BEES SANDSTONE, HILTON BECK

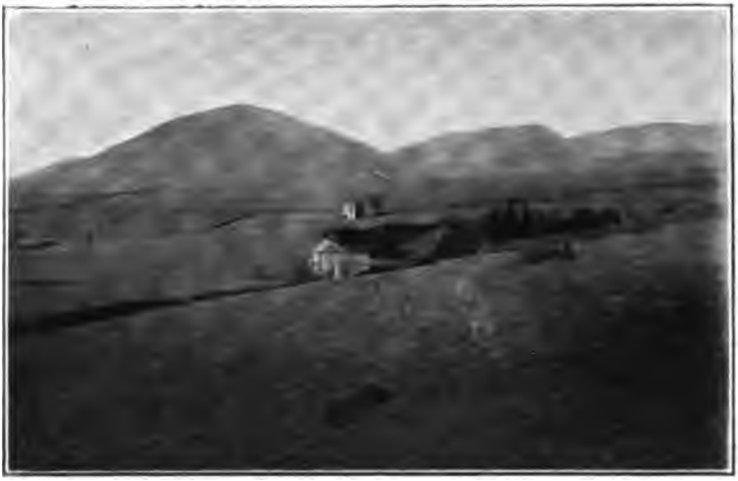


FIG. 2.—DUFTON PIKE (TO LEFT), BROWNBER (CENTRE), AND THE CARBONIFEROUS SCARP (TO RIGHT).

Photos by W. G. Fearnsides.

To face page 194.

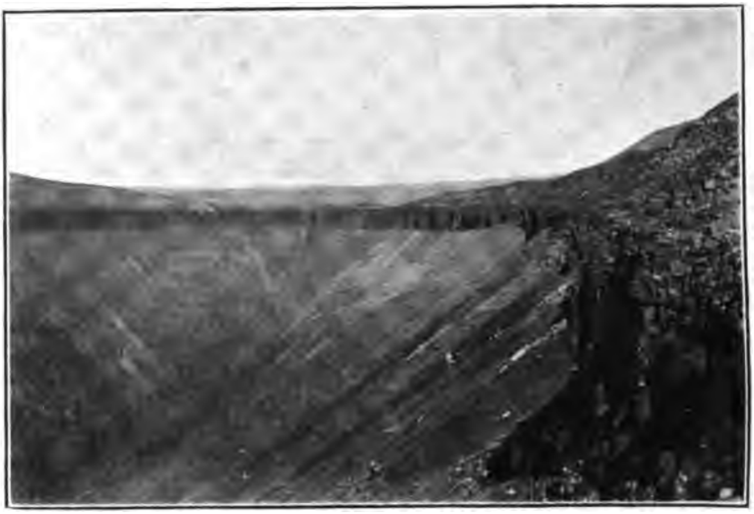


FIG. 1.—HIGH CUP GILL. THE EAST END SHOWING CLIFF OF WHIN SILL.

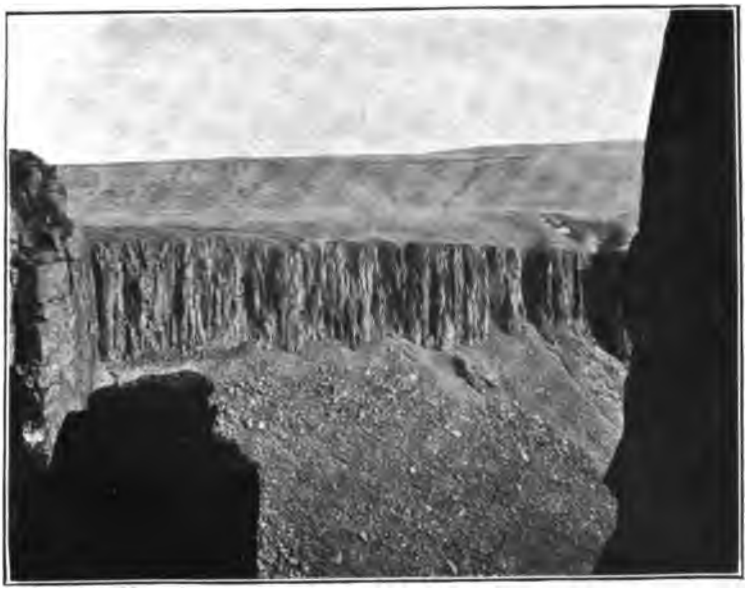
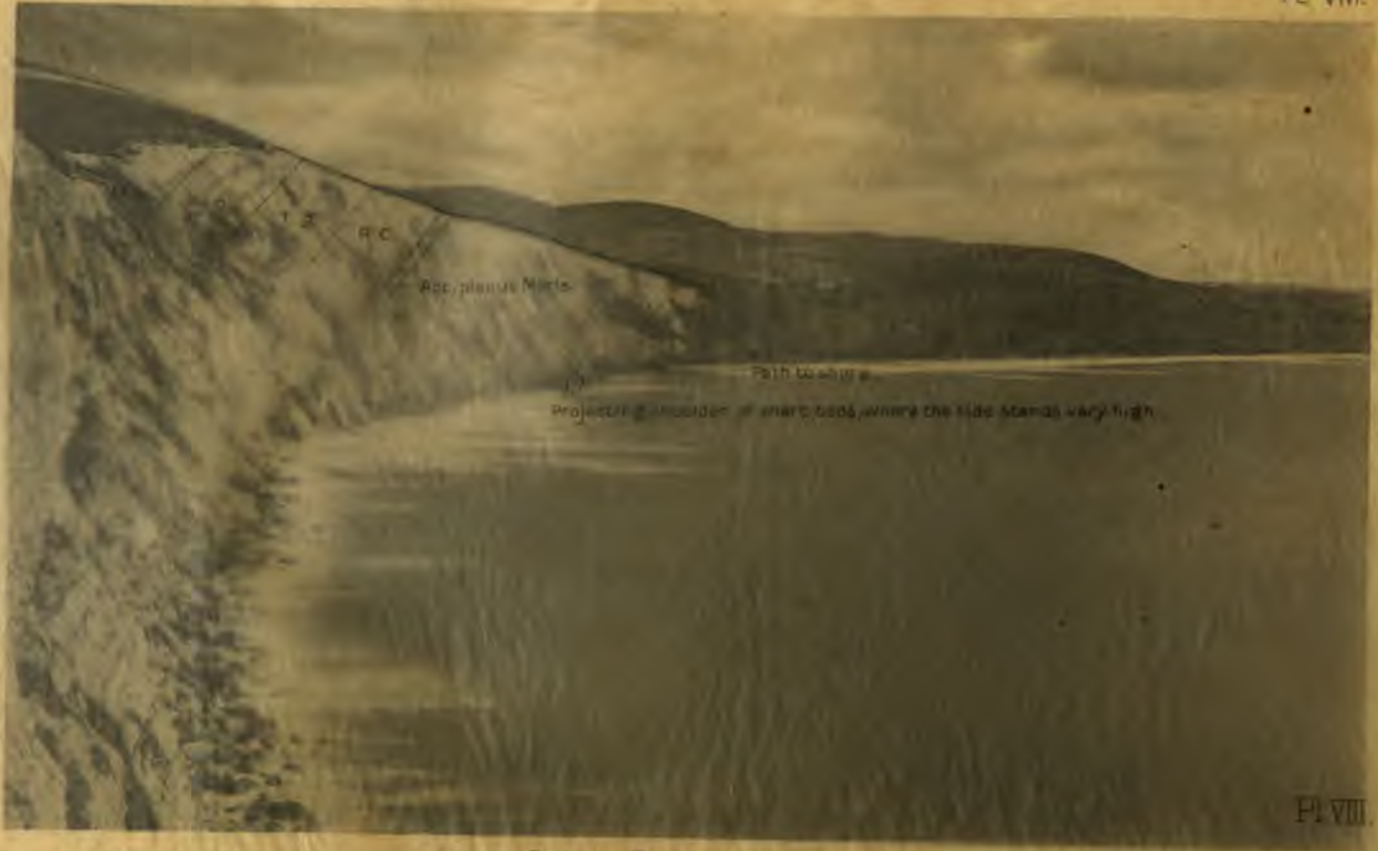
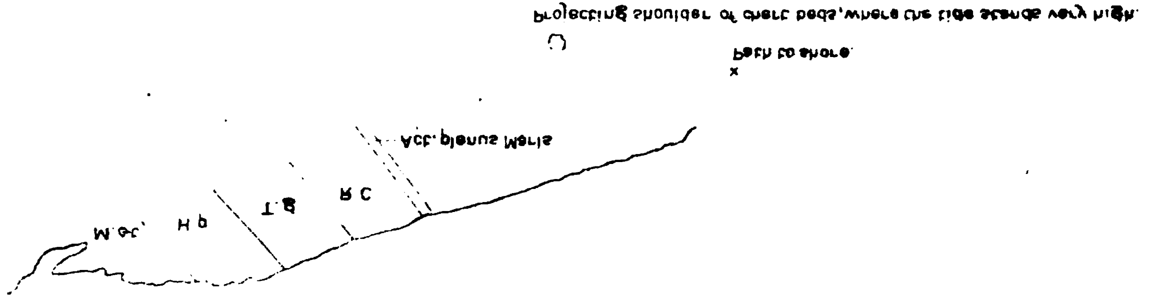


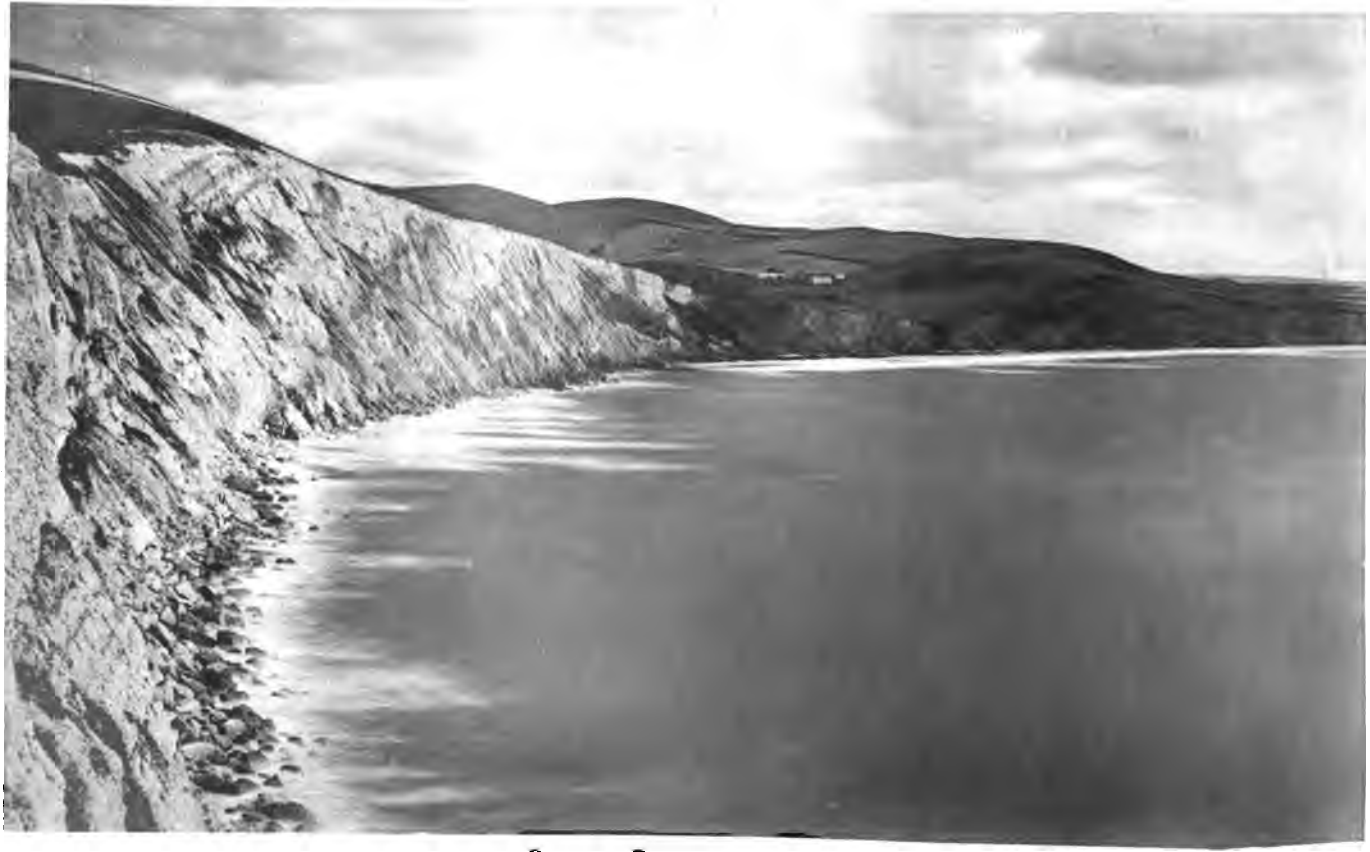
FIG. 2—HIGH CUP GILL. THE SOUTH SIDE NEAR THE "NICK," SHOWING COLUMNAR STRUCTURE OF WHIN SILL AND BENCH OF OLD VALLEY BEYOND.
Photos by W. G. Fearnsides.


0
1 2
R C
Act. plenus Marls
Path to shore
Projecting shoulder of marl beds, where the tide stands very high
Pl. VIII.

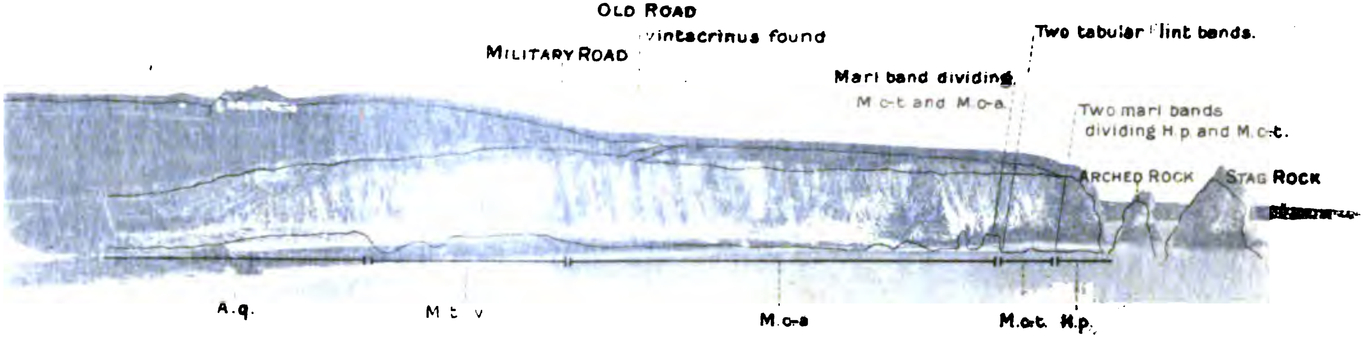
COMPTON BAY FROM THE WEST.

Pl.VIII.

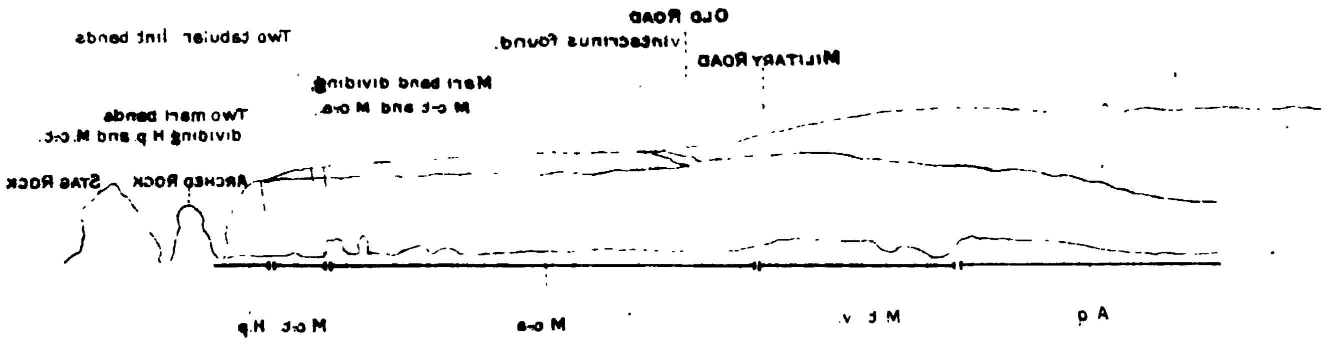

Projecting shoulder of chert beds, where the tide stands very high.
Path to shore
Act. plenus Marls
R C
T.g
H p
M.oc.



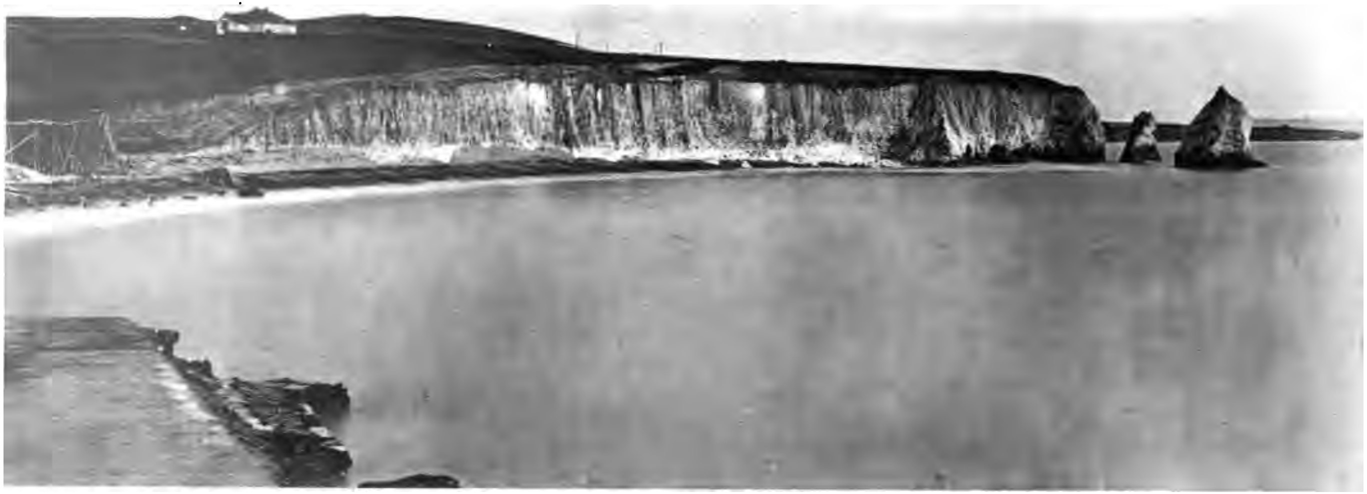
COMPTON BAY FROM THE WEST.


OLD ROAD
Uintacrinus found
MILITARY ROAD
Marl band dividing
M.c-t and M.c-a.
Two tabular flint bands.
Two marl bands
dividing H.p. and M.c-t.
ARCHED ROCK
STAG ROCK
A.q.
M t v
M.c-a
M.c-t.
H.p.

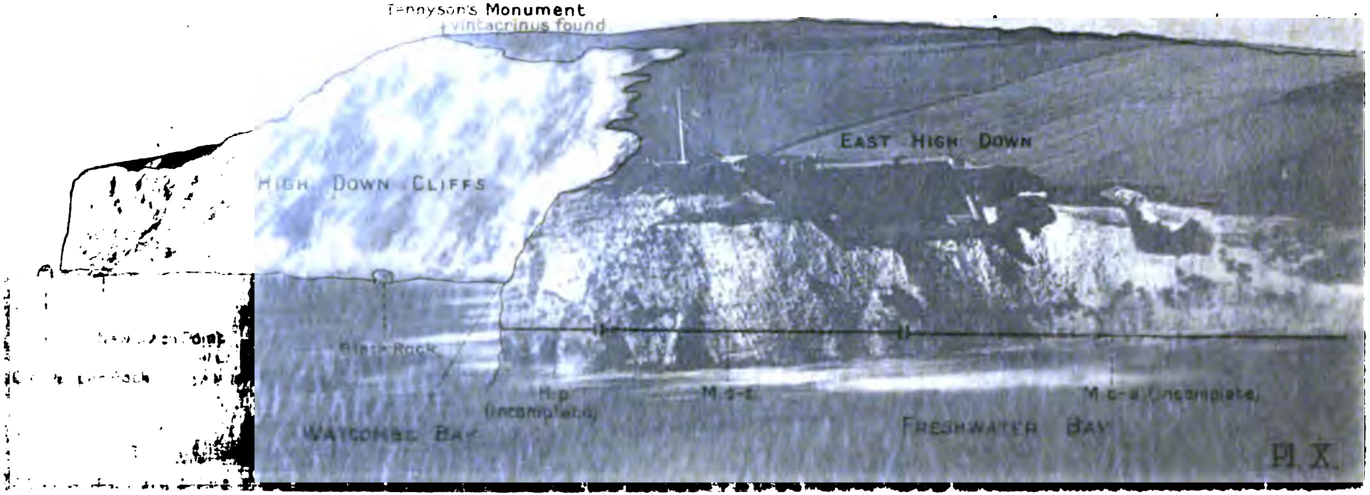
Pl. IX.


Two tabular flint bands
Two marl bands
dividing H p and M c-t.
Marl band dividing
M c-t and M c-a.
OLD ROAD
Uintacrinus found.
MILITARY ROAD
STAG ROCK
ARCHED ROCK
H.p
M c-t
M c-a
M t v.
A q

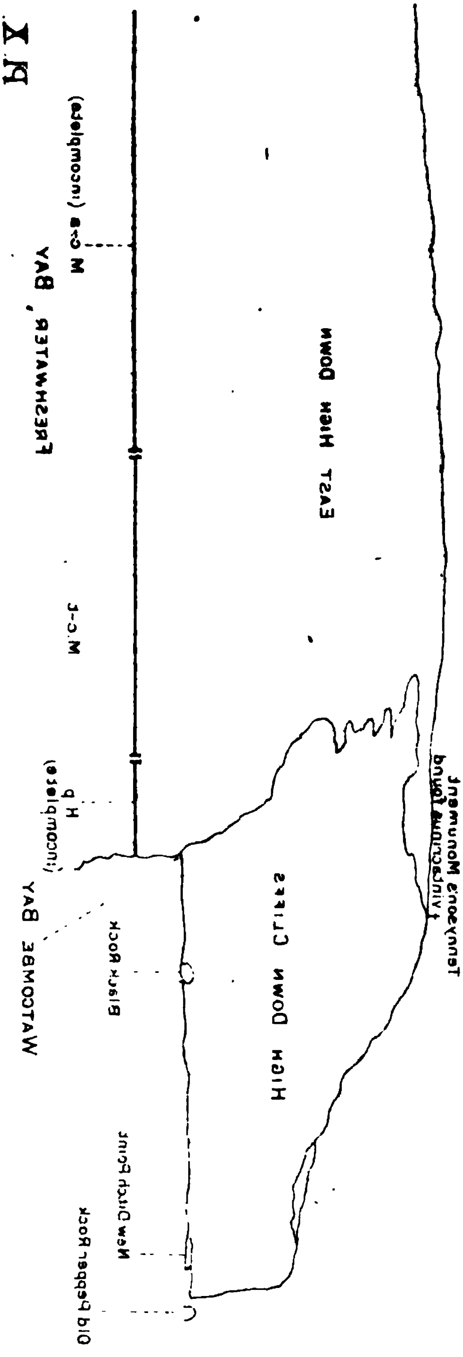
Pl. IX.

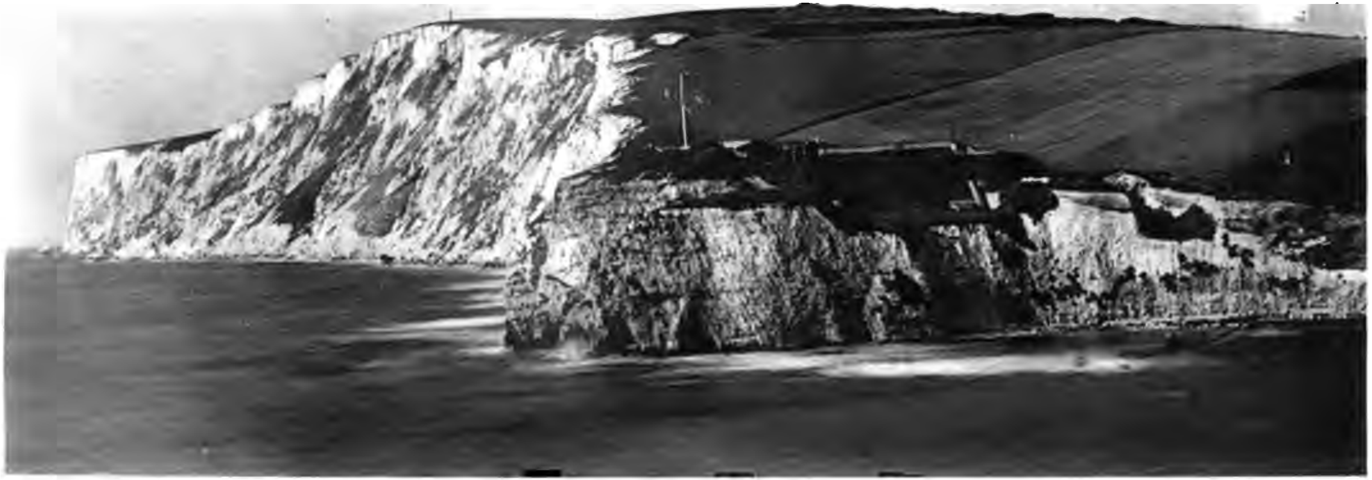


THE EASTERN SIDE OF FRESHWATER BAY.

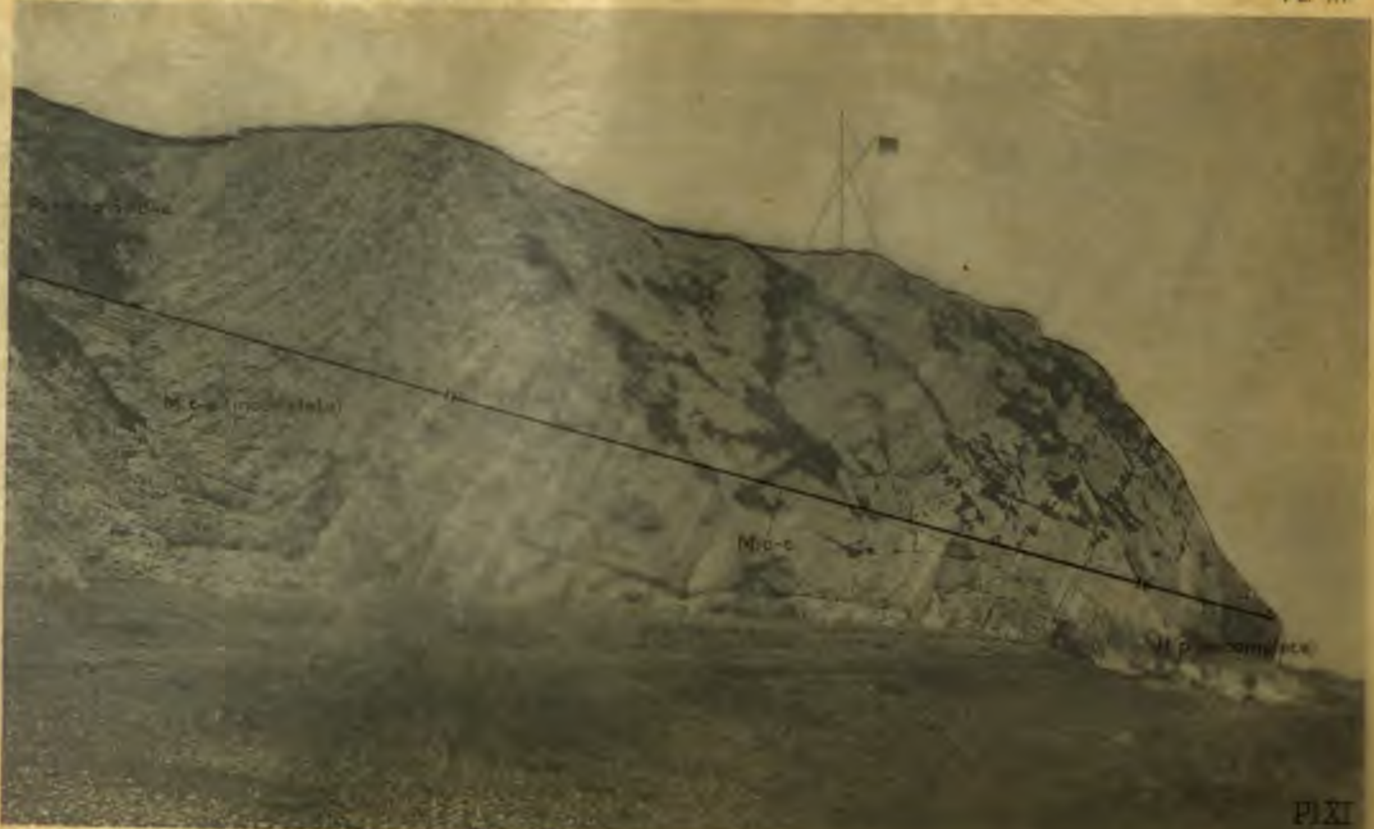


THE WESTERN SIDE OF [illegible]

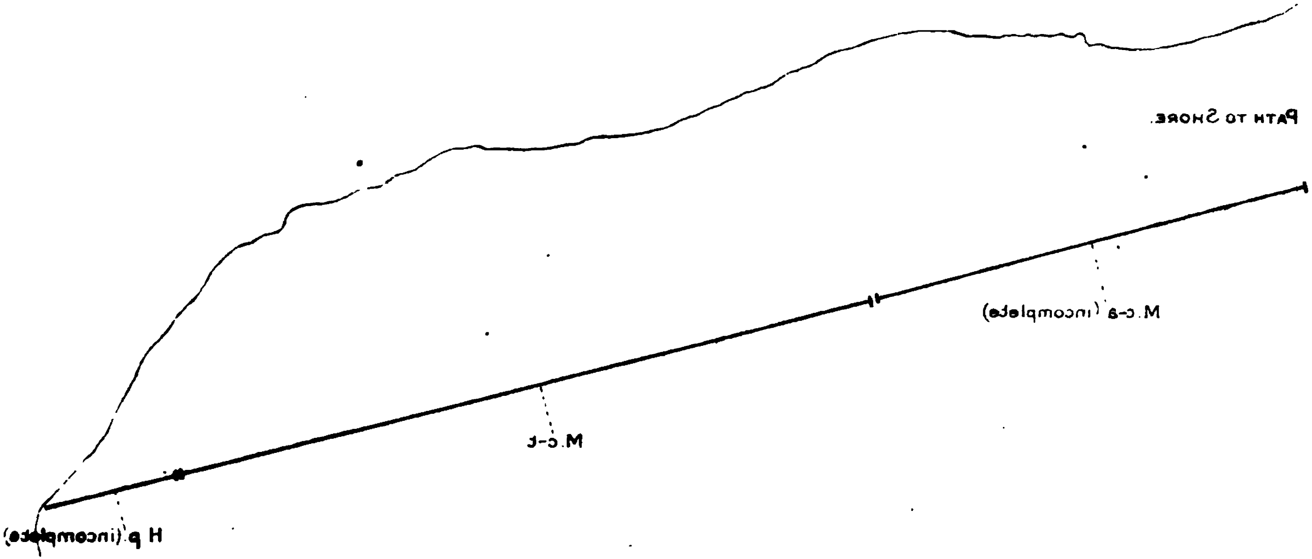

Pl X
FRESHWATER, BAY
M c-a (incomplete)
M c-t
H p (incomplete)
WATCOMBE BAY
EAST HIGH DOWN
HIGH DOWN CLIFFS
Tennyson's Monument
+ Uintacrinus found
Black Rock
New Ditch Point
Old Pepper Rock



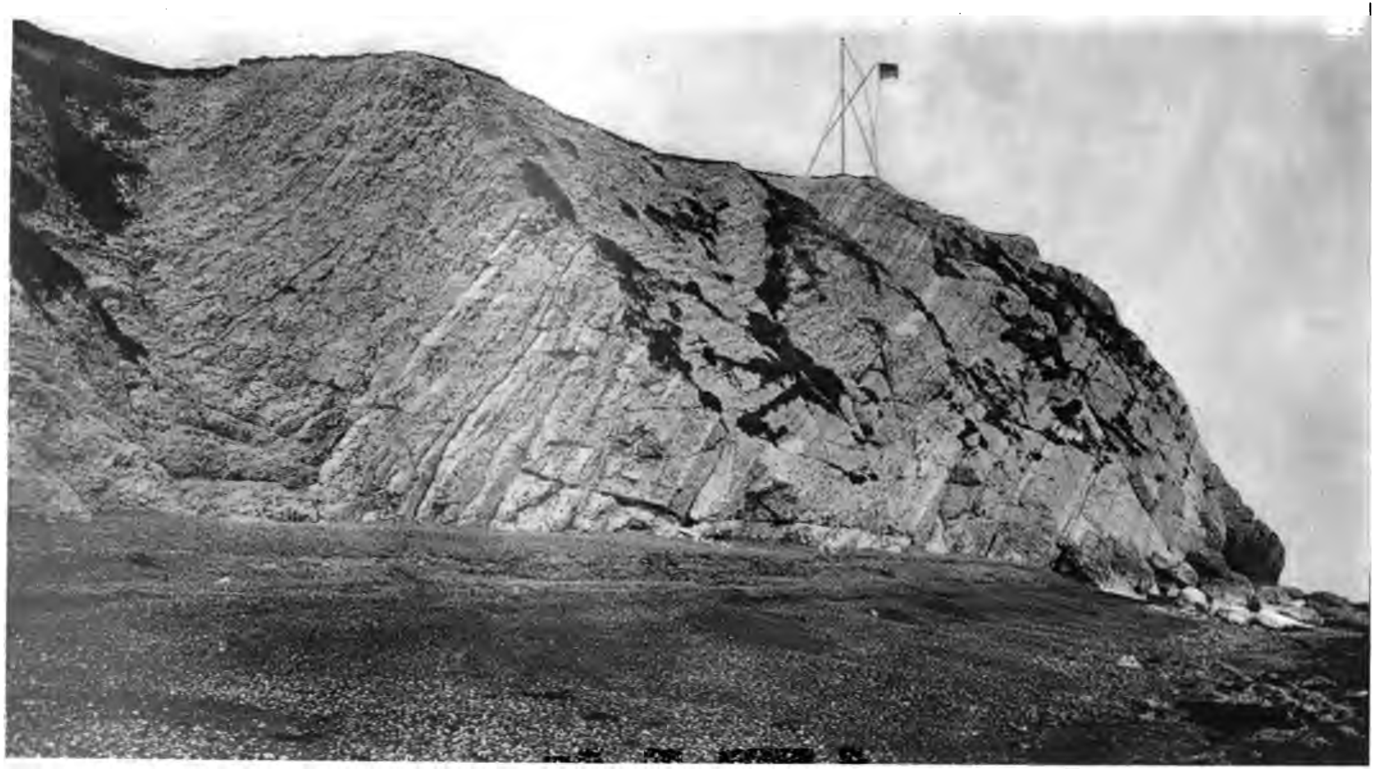
THE WESTERN SIDE OF FRESHWATER BAY, WITH HIGH DOWN CLIFFS.



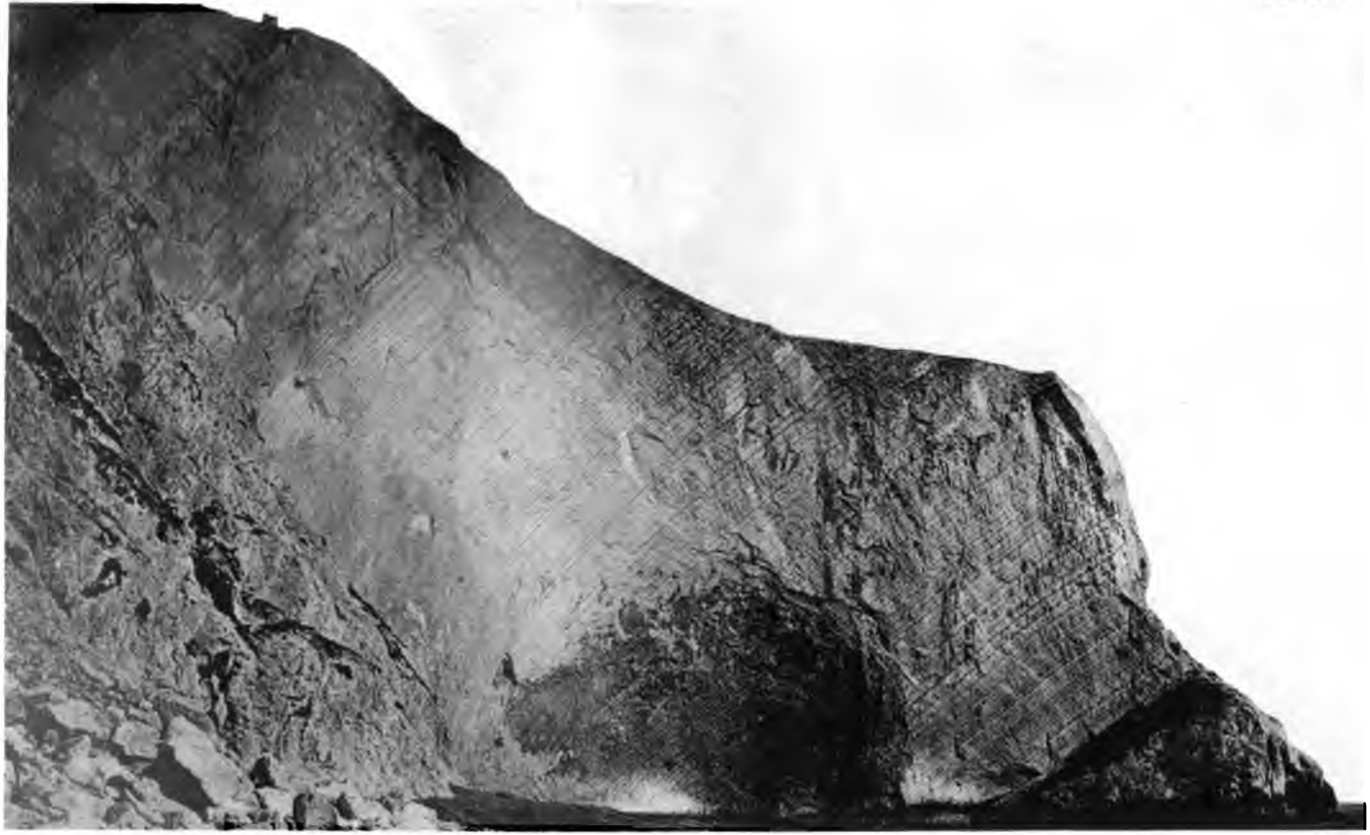
THE EASTERN [illegible]



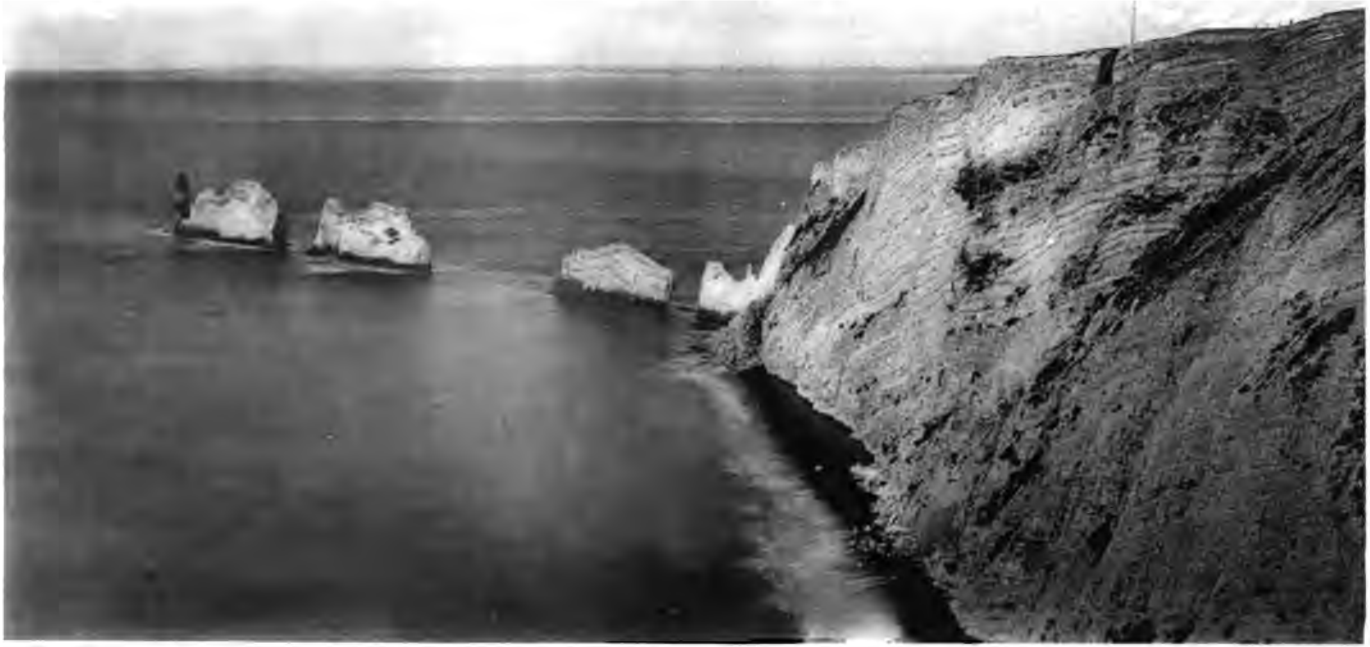
Pl. XI



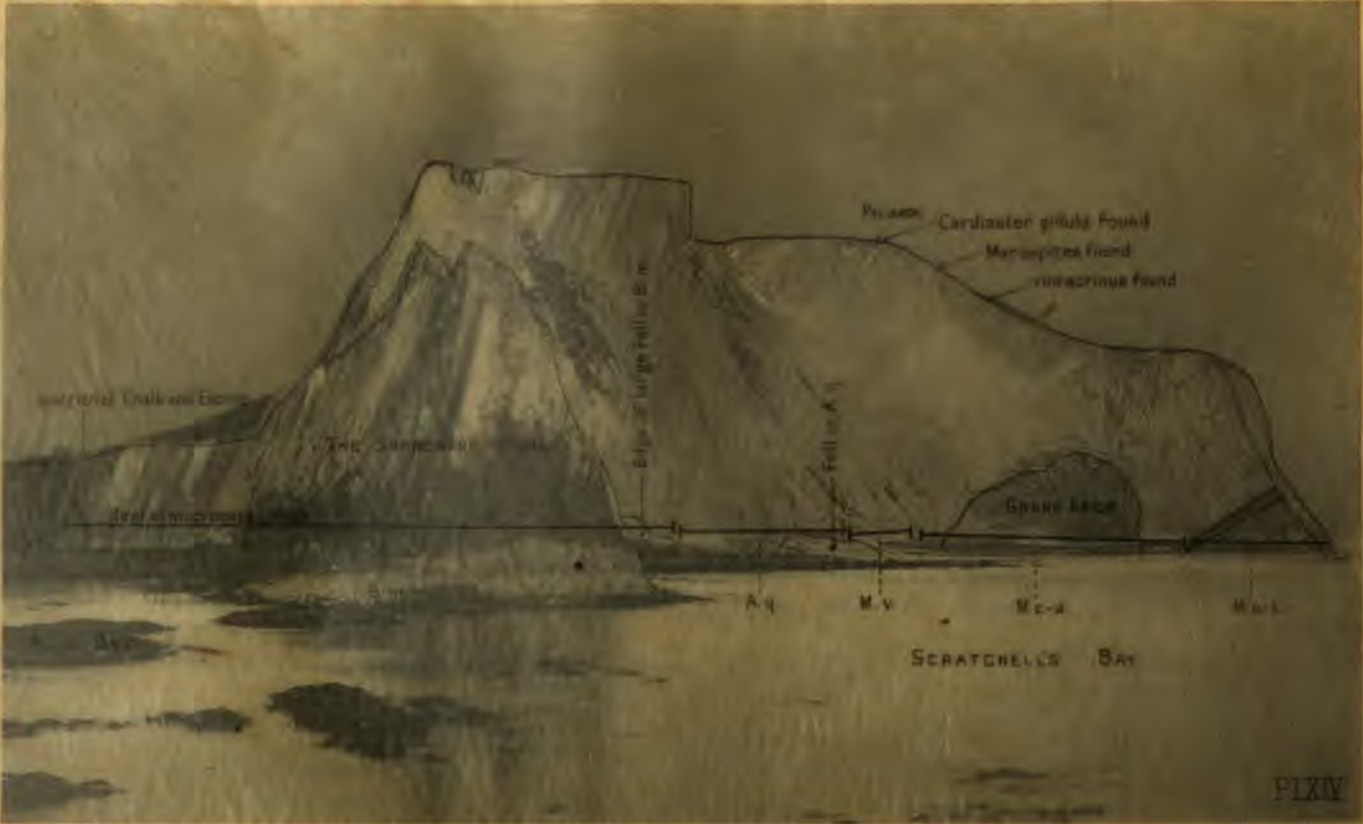
The Eastern side of Watcombe Bay.



THE EASTERN SIDE OF SCRATCHELL'S BAY, WITH THE GRAND ARCH AND SUN CORNER.

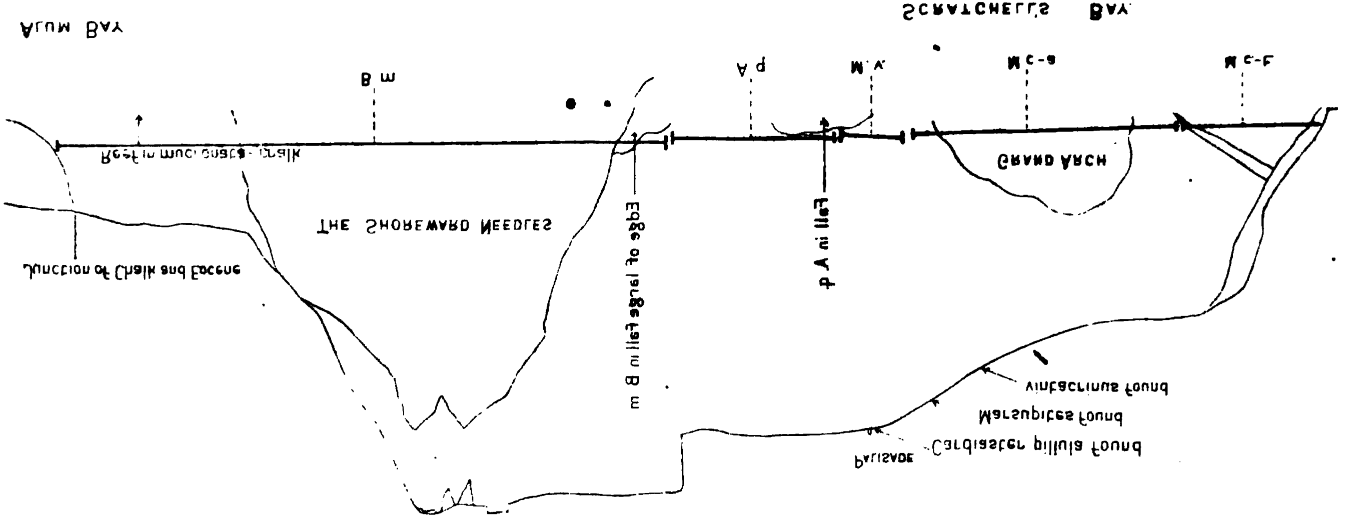


The Western side of Scratchell's Bay, with the Needles.

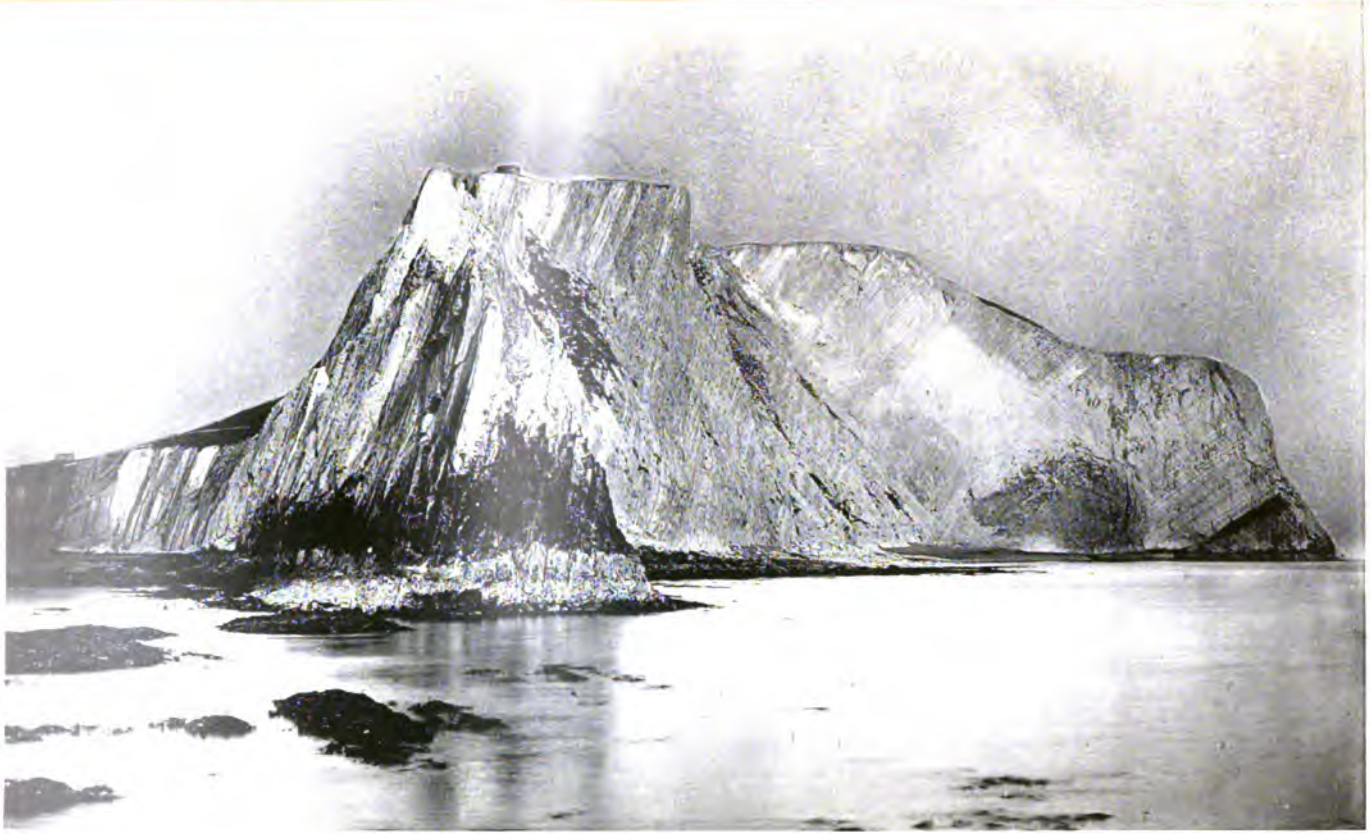


ALUM BAY AND SCRATCHELL'S BAY FROM THE THIRD NEEDLE.

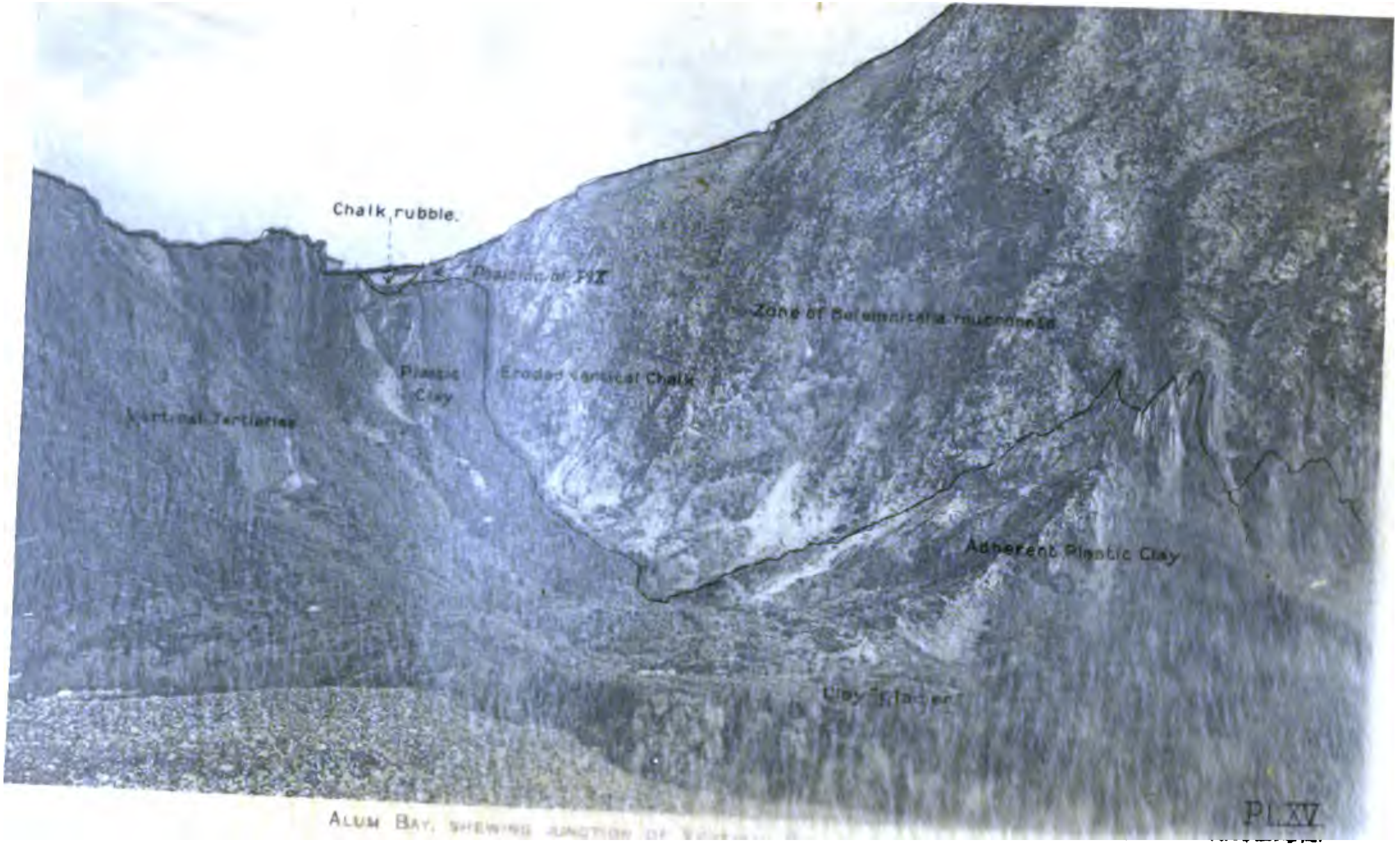
Pl. XIV.



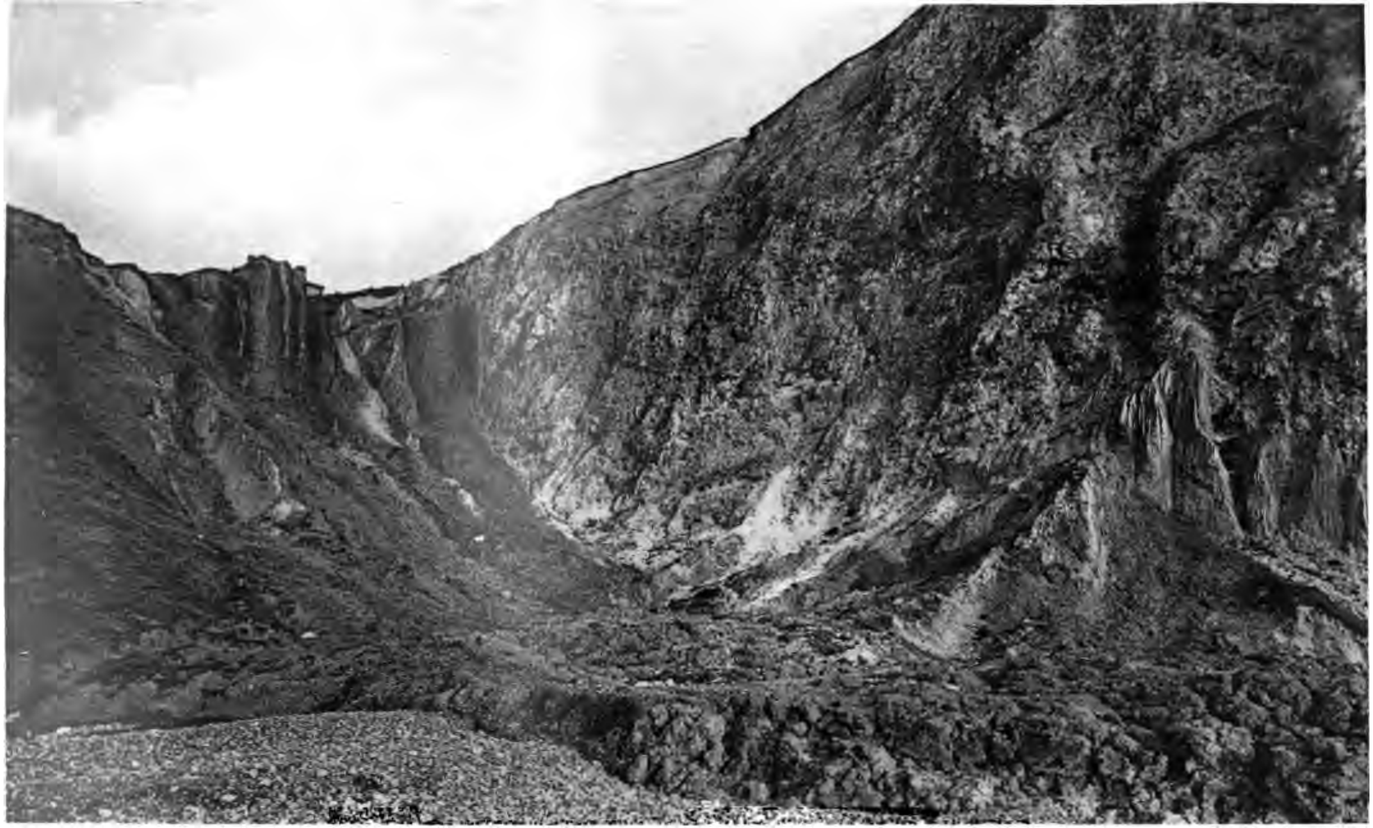
Scratchell's Bay
Alum Bay
M c-t
M c-a
M. v.
A p
B m
Grand Arch
Fall in A p
Edge of large Fall in B m
The Shoreward Needles
Reef in mucronata-chalk
Junction of Chalk and Eocene
Palisade
Cardiaster pillula found
Marsupites found
vintacrinus found



Alum Bay and Scratchell's Bay from the third Needle.

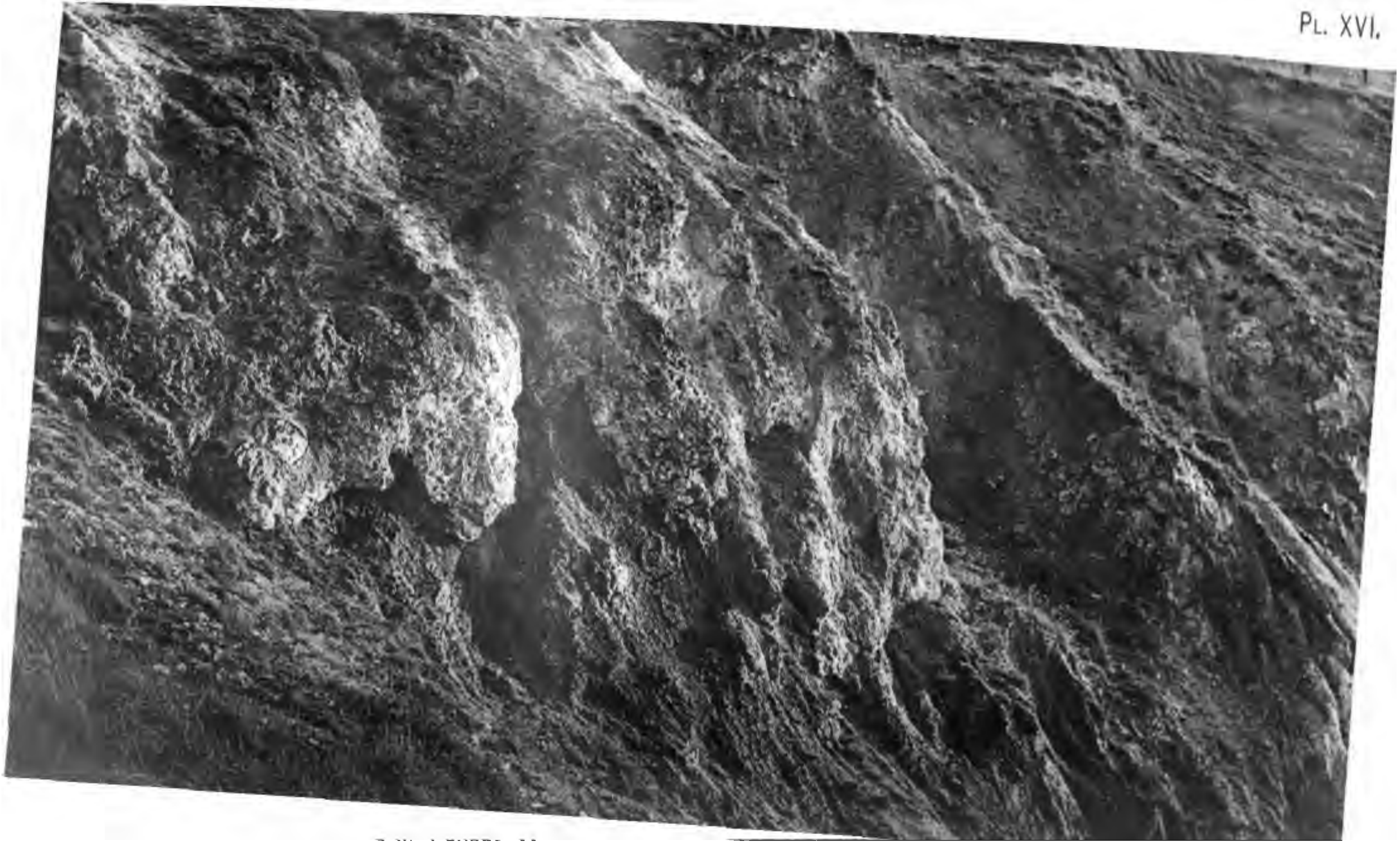


ALUM BAY, SHEWING JUNCTION OF VERTICAL

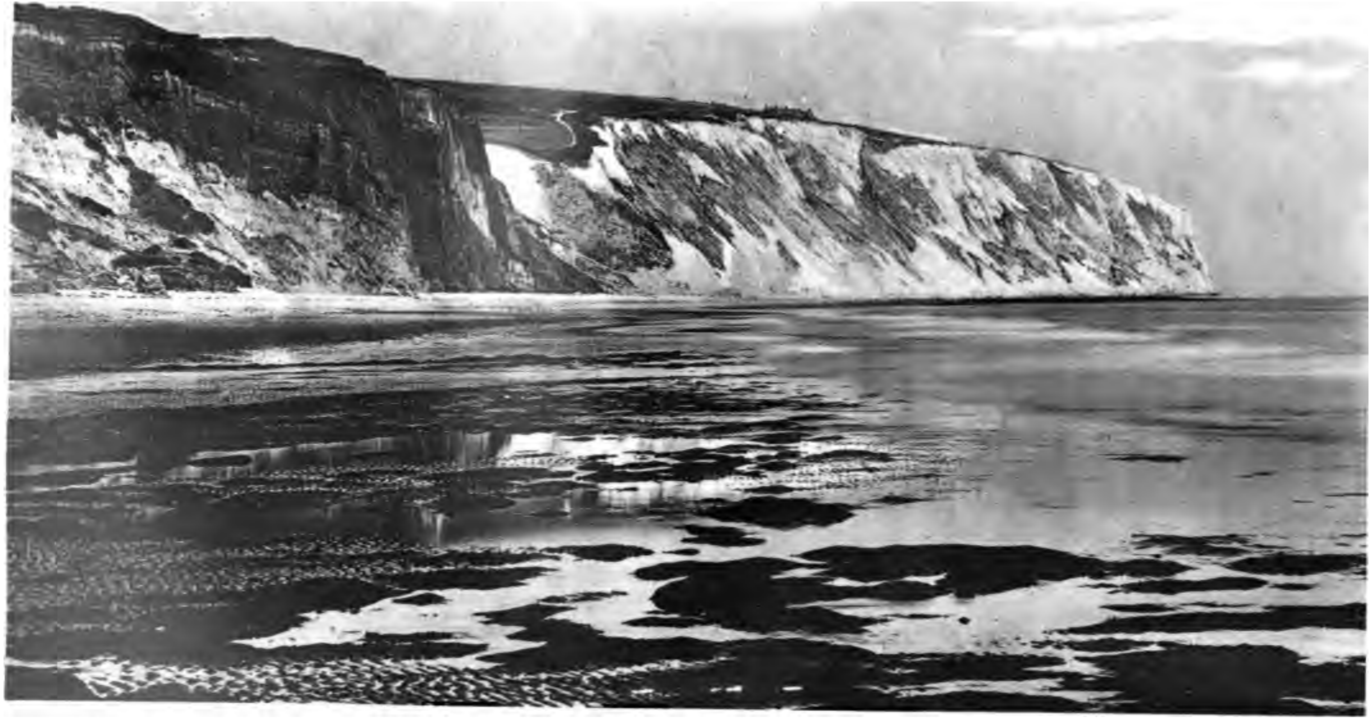


ALUM BAY, SHEWING JUNCTION OF VERTICAL CHALK AND TERTIARIES.

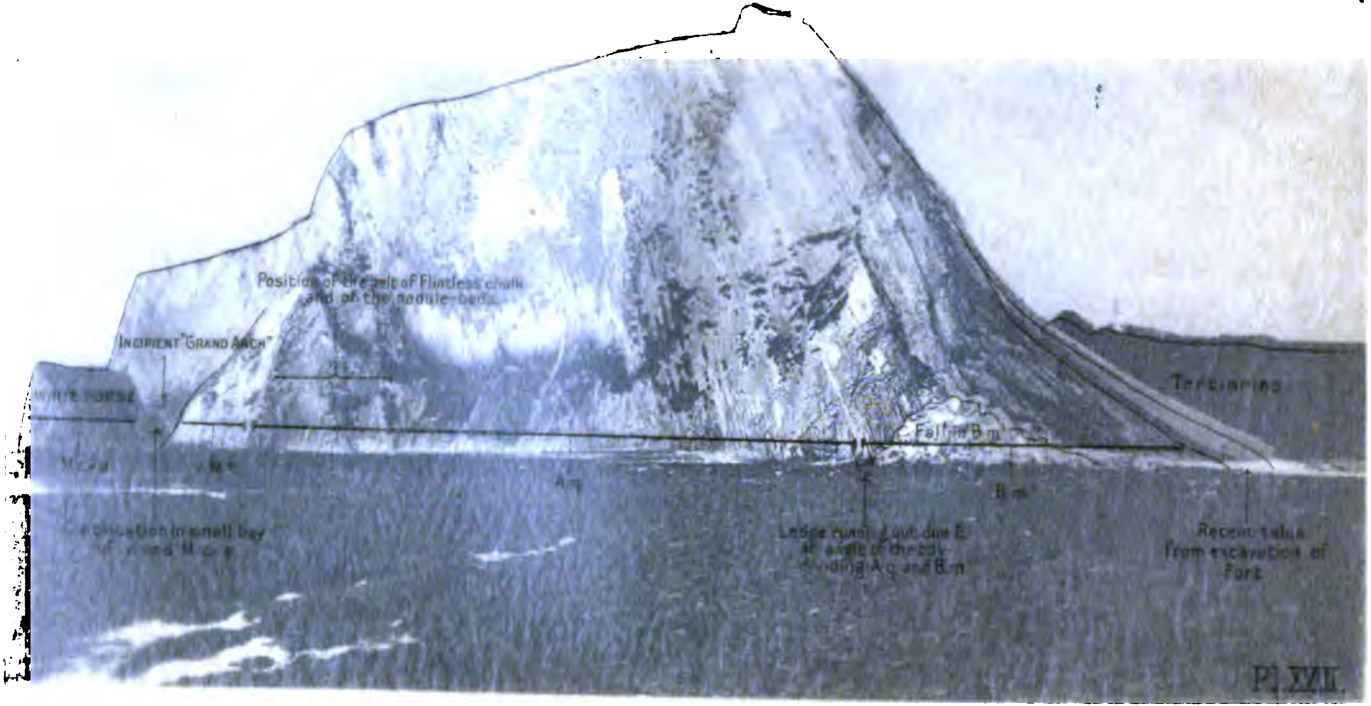
PL. XVI.

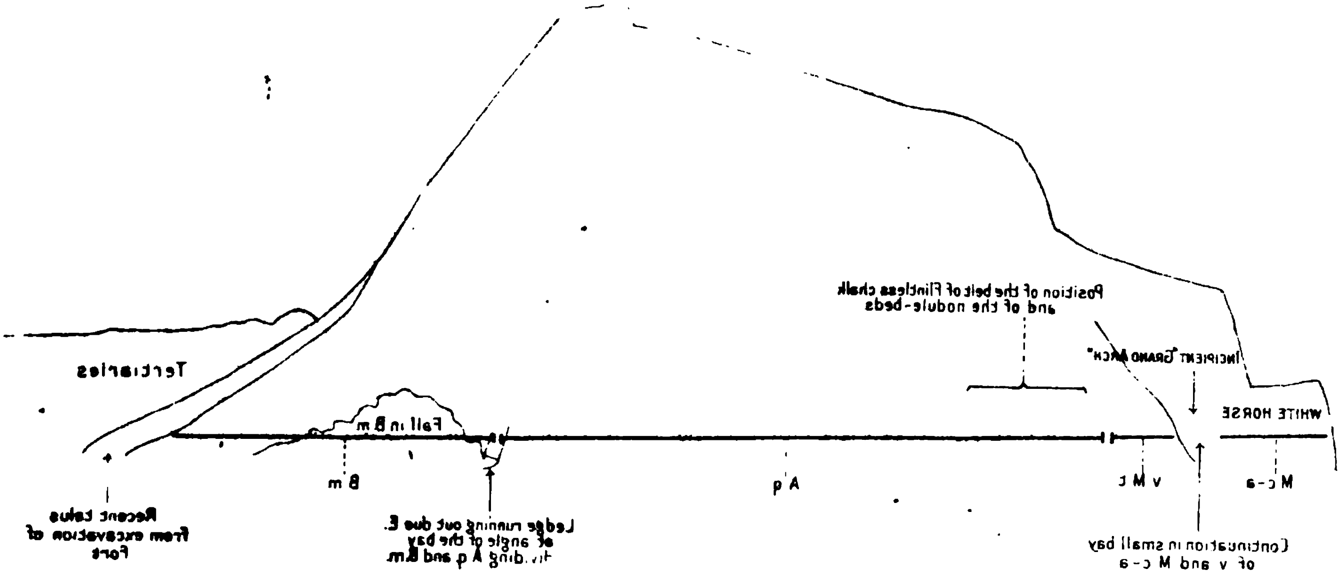


PL. XVII.

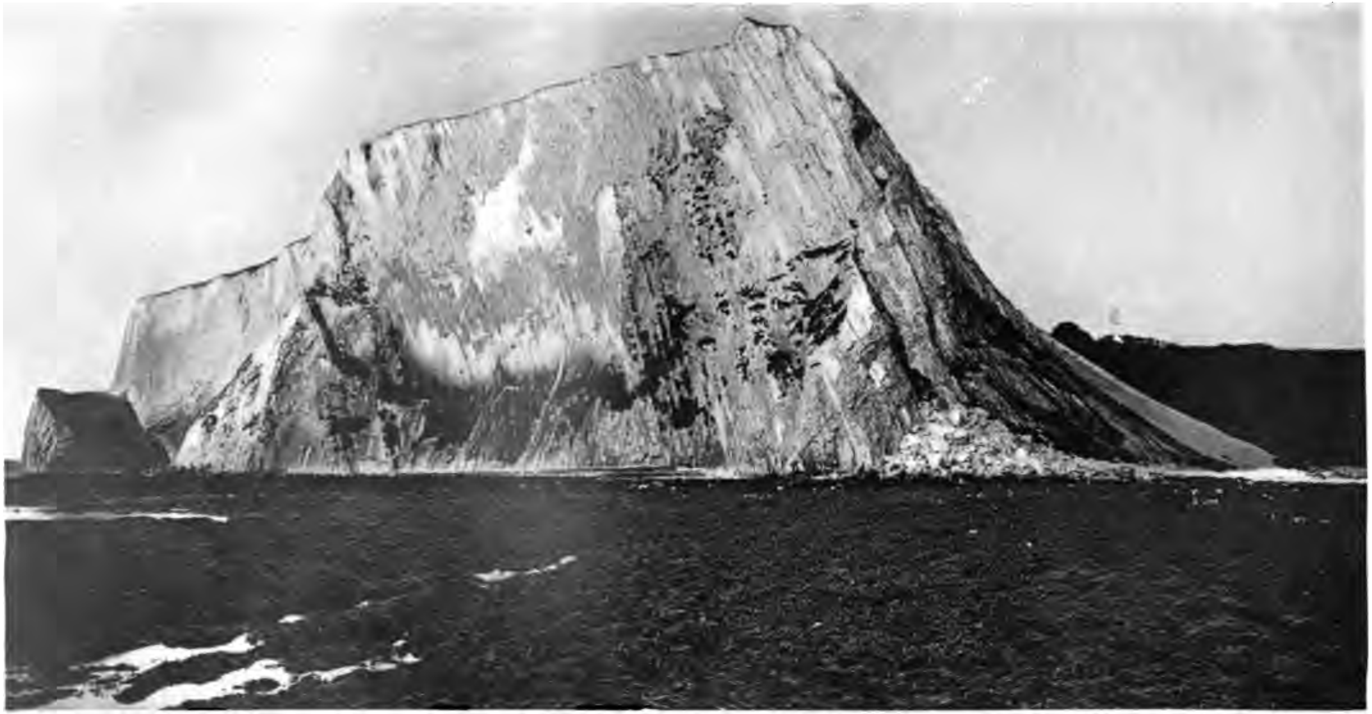


THE SOUTHERN CLIFF OF THE CULVER FROM SANDOWN BAY.

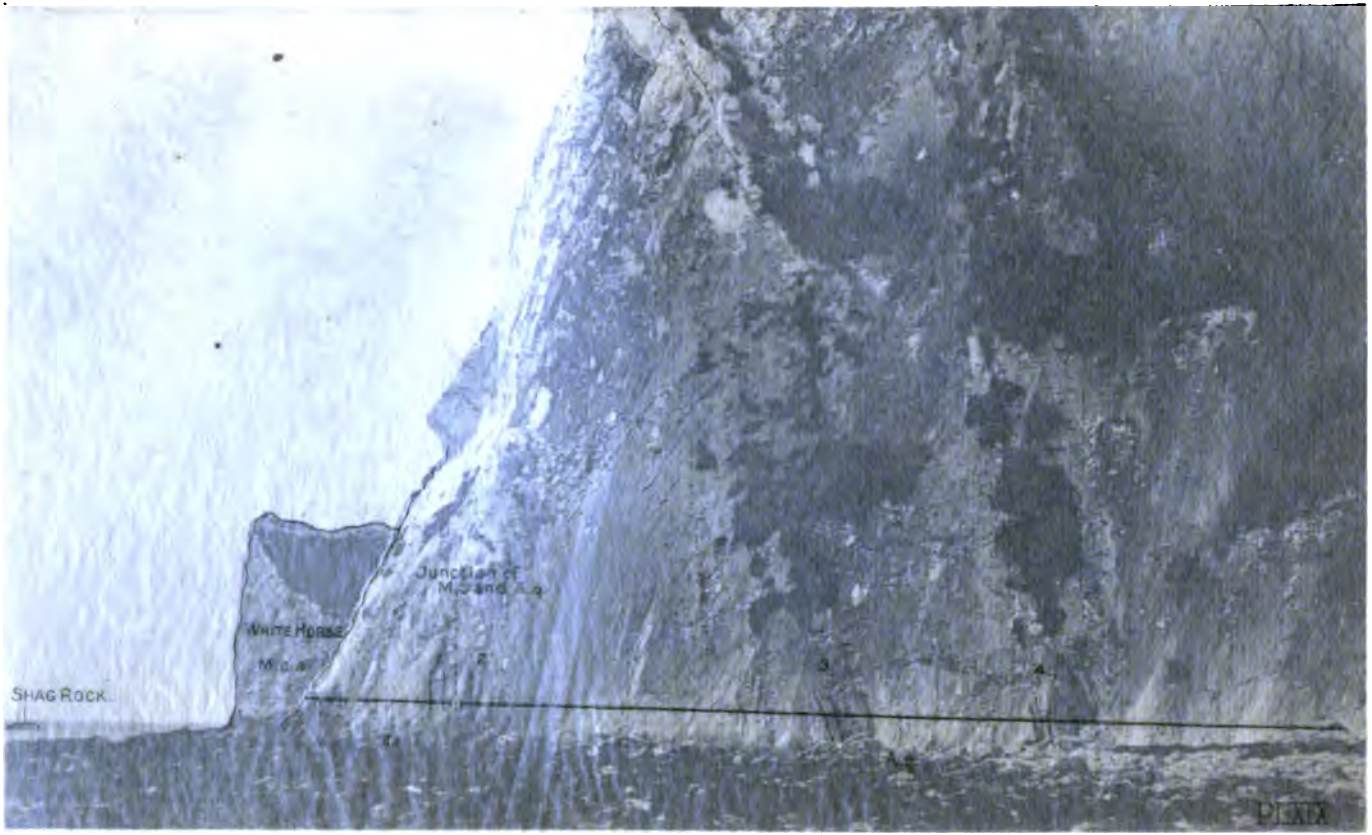

Position of the belt of Flintless chalk
and of the nodule-beds.
INCIPIENT "GRAND ARCH"
WHITE HORSE
M.c.a
M.c.t
Dislocation in small bay
of A.q and M.c.a
A.q
Fall in B.m
B.m
Ledge running out due E
at angle of the cliff
dividing A.q and B.m
Tertiaries
Recent talus
from excavation of
Fort
Pl. XVI.


Tertiaries
Fall in B m
Position of the belt of Flintless chalk and of the nodule-beds
INCIPIENT "GRAND ARCH"
WHITE HORSE
B m
A q
v M c
M c-a
Recent talus from excavation of Fort
Ledge running out due E. of angle of the bay dividing A q and B m.
Continuation in small bay of v and M c-a

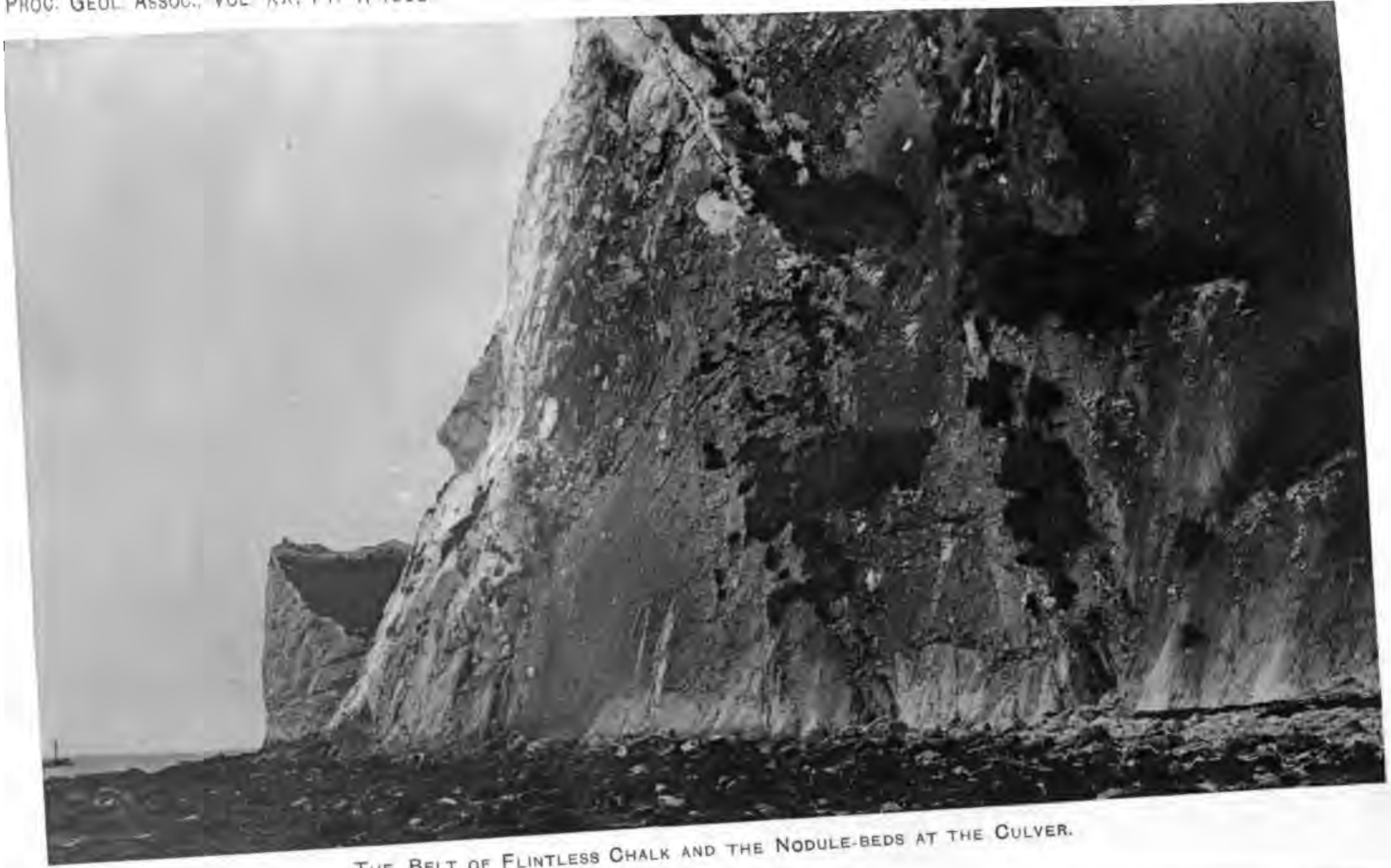
Pl. XVIII.



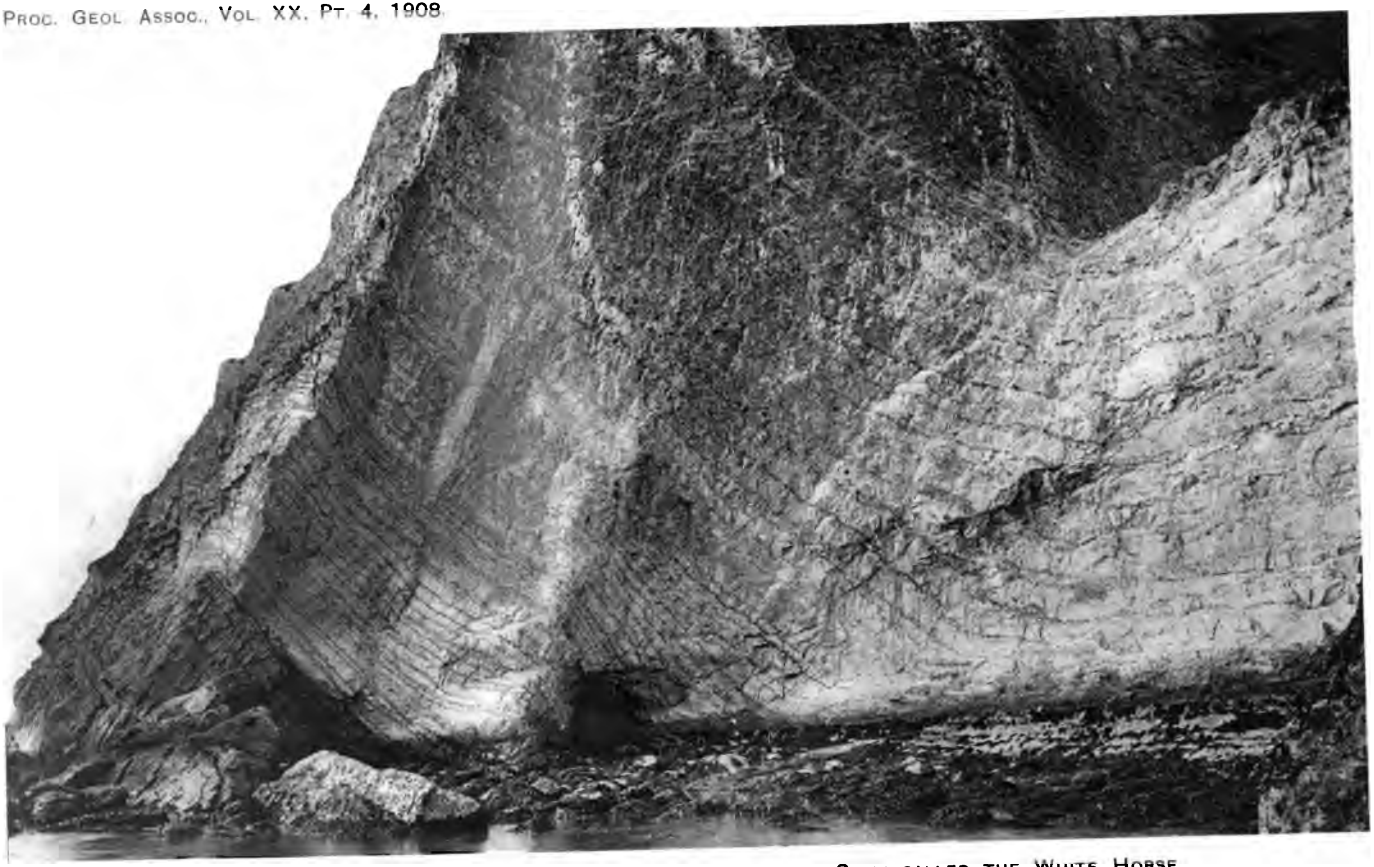
GENERAL VIEW OF THE CULVER, SHEWING THE EASTERN CLIFF AND THE WHITE CLIFF PROPER.



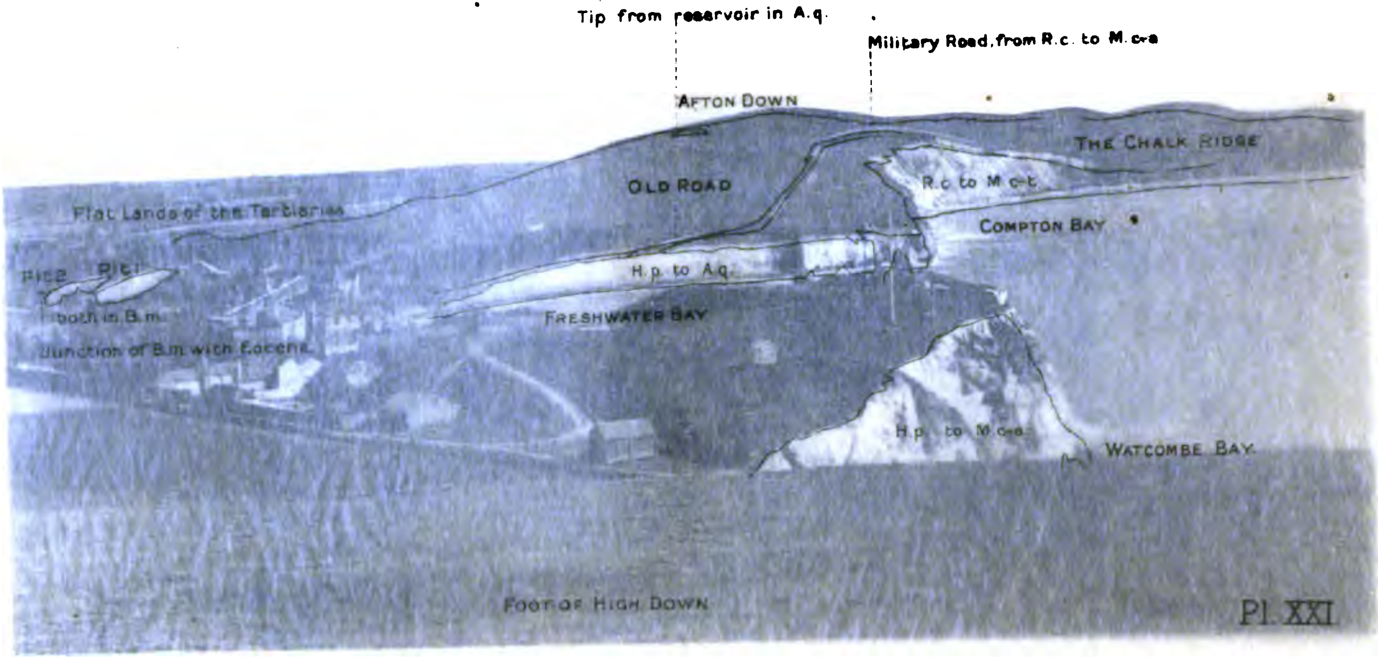
THE BELT OF FLINTLESS CHALK AND THE NODULE BEDS AT THE CULVER.

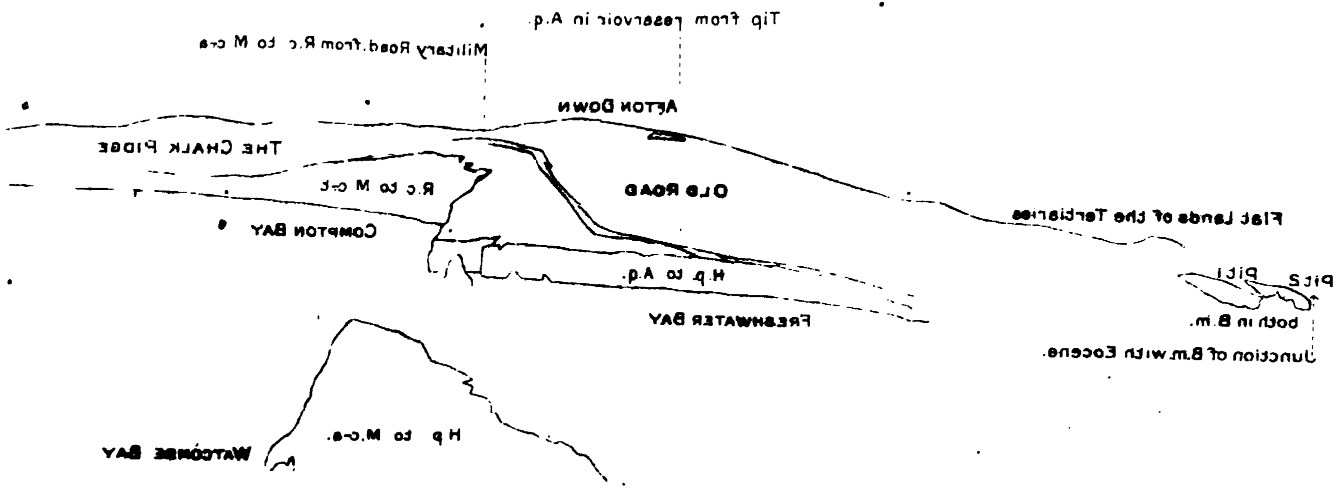


THE BELT OF FLINTLESS CHALK AND THE NODULE-BEDS AT THE CULVER.

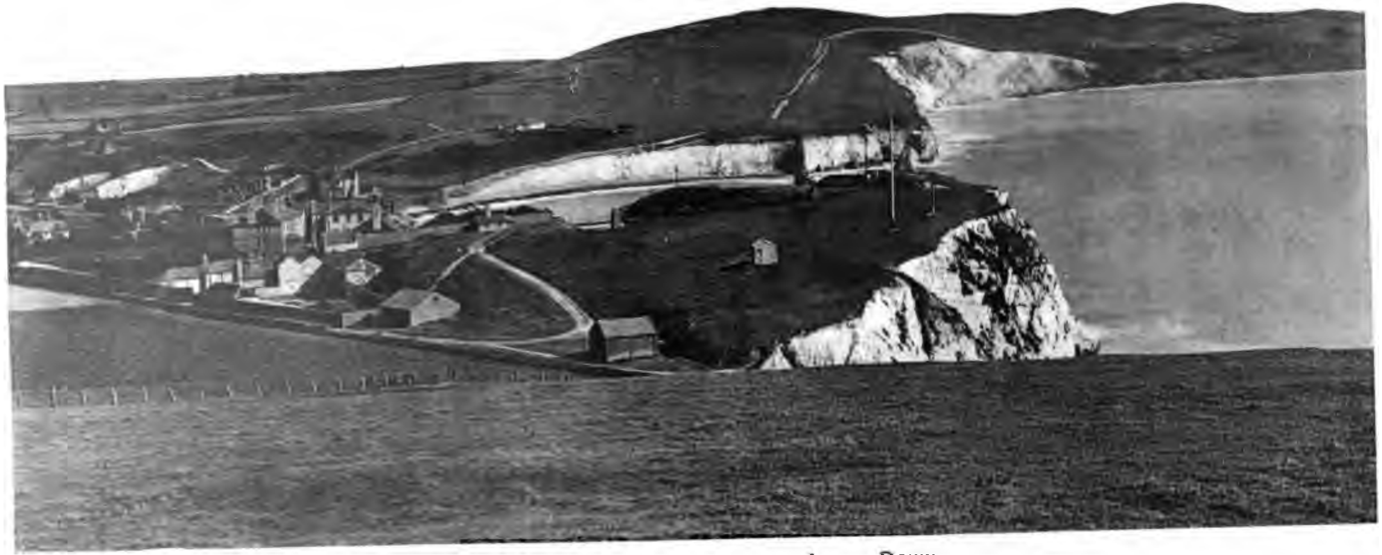


The Nostrils, Culver Cliff, with part of the projecting Cliff called the White Horse.

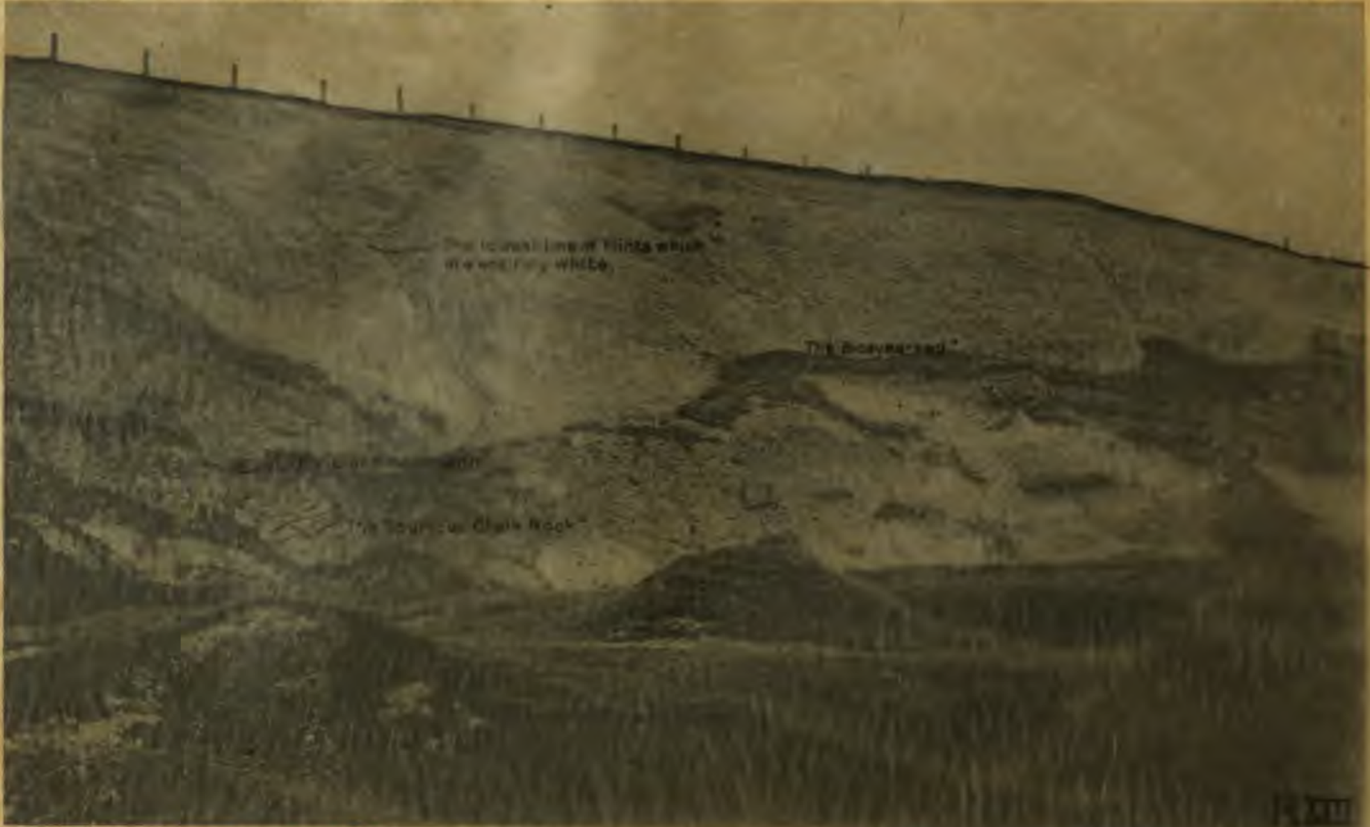

Tip from reservoir in A.q.
Military Road, from R.c. to M.c-a
Afton Down
Old Road
The Chalk Ridge
R.c to M.c-t
Compton Bay
Flat Lands of the Tertiaries
Pit 2
Pit 1
both in B.m.
Junction of B.m with Eocene
H.p. to A.q.
Freshwater Bay
H.p. to M.c-a
Watcombe Bay
Foot of High Down
Pl. XXI


Tip from reservoir in A.g.
Military Road from R.c. to M.c-a
Afton Down
The Chalk Ridge
R.c. to M.c-t.
Old Road
Compton Bay
Flat Lands of the Tertiaries
H.p. to A.g.
Pit 1
Pit 2
Freshwater Bay
both in B.m.
Junction of B.m. with Eocene.
H.p. to M.c-a.
Watcombe Bay
Foot of High Down

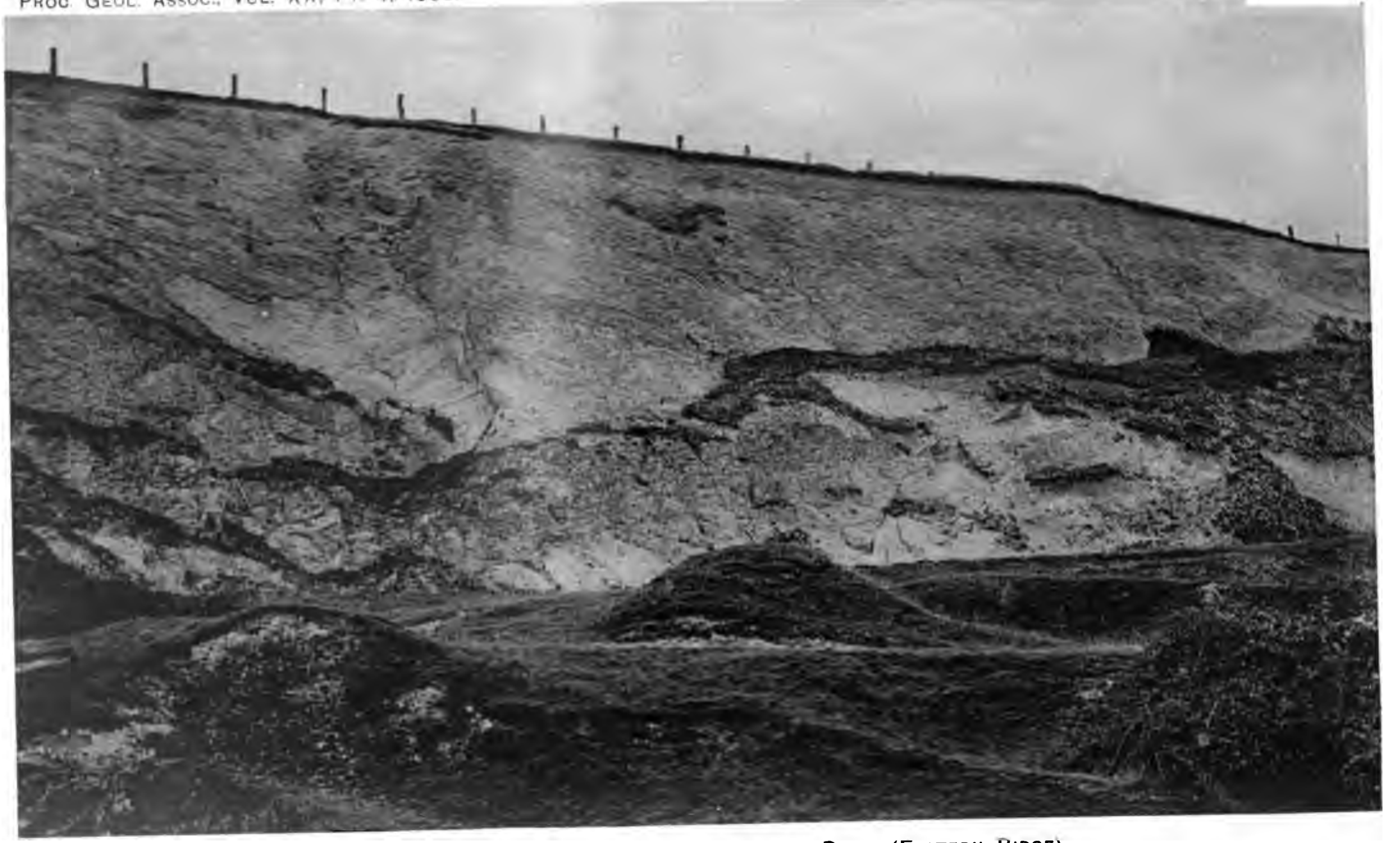
Pl. XXI.



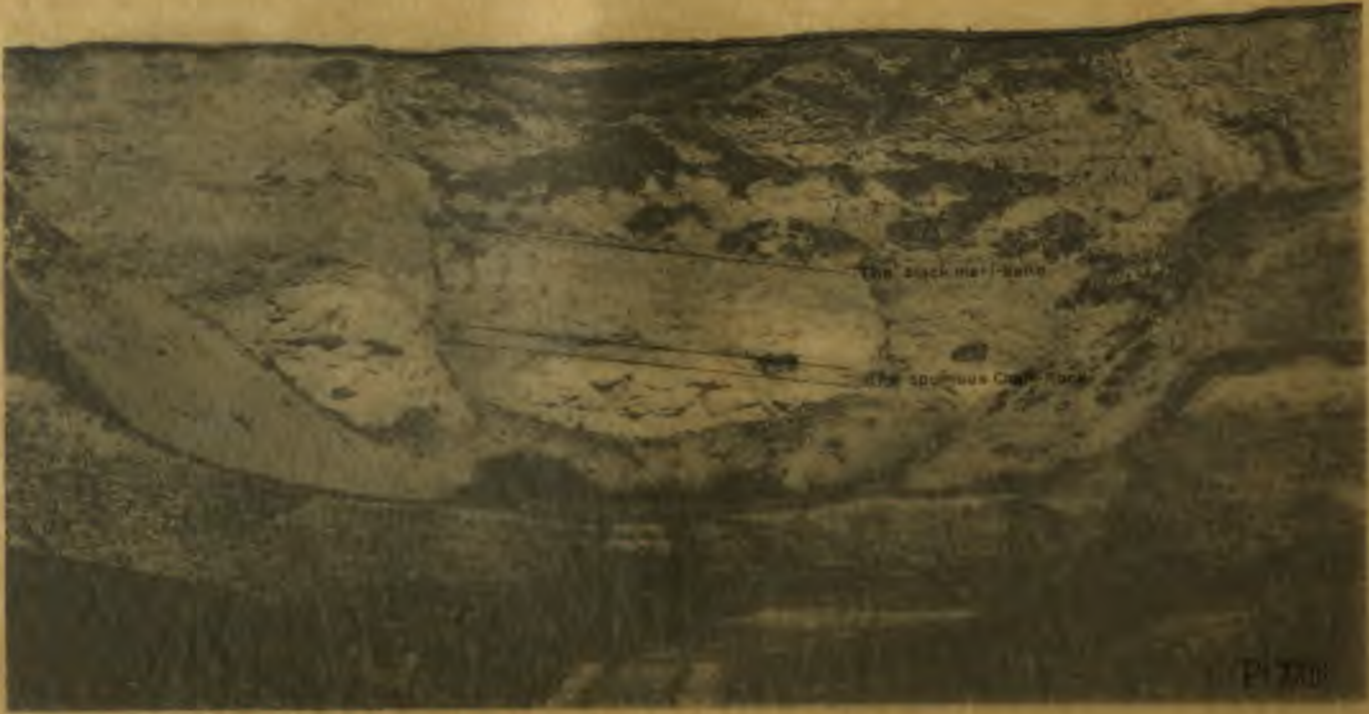
VIEW FROM EAST HIGH DOWN TO AFTON DOWN.


The lowest line of Flints which
white.
"Chalk Rock"

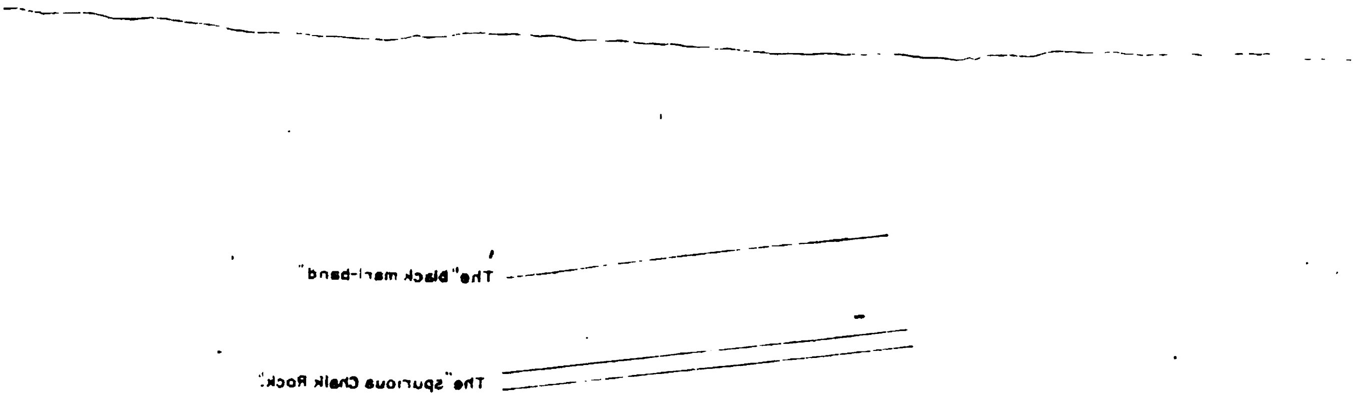
PL. XXII.



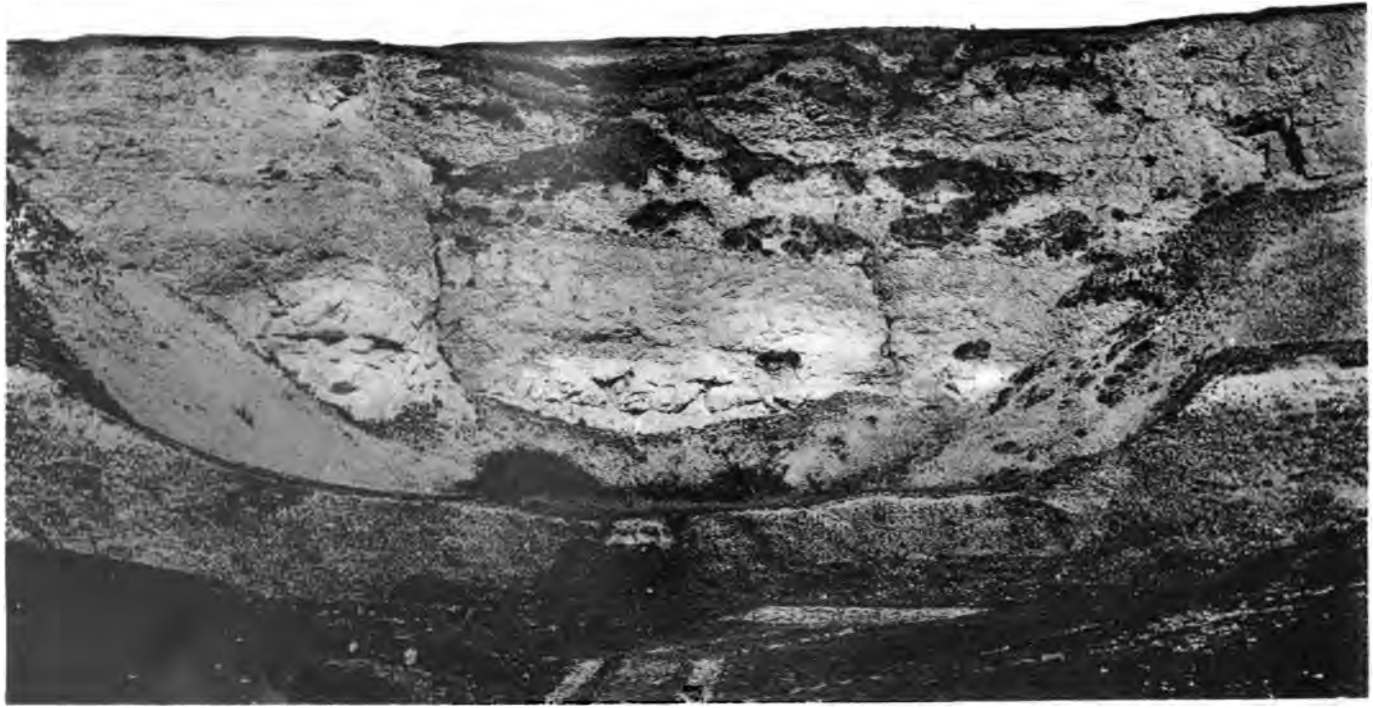
PIT NO. 37 ON THE SOUTH SIDE OF BRADING DOWN (EASTERN RIDGE).



Pit No. 17 at Broughton Down [illegible] Hants.



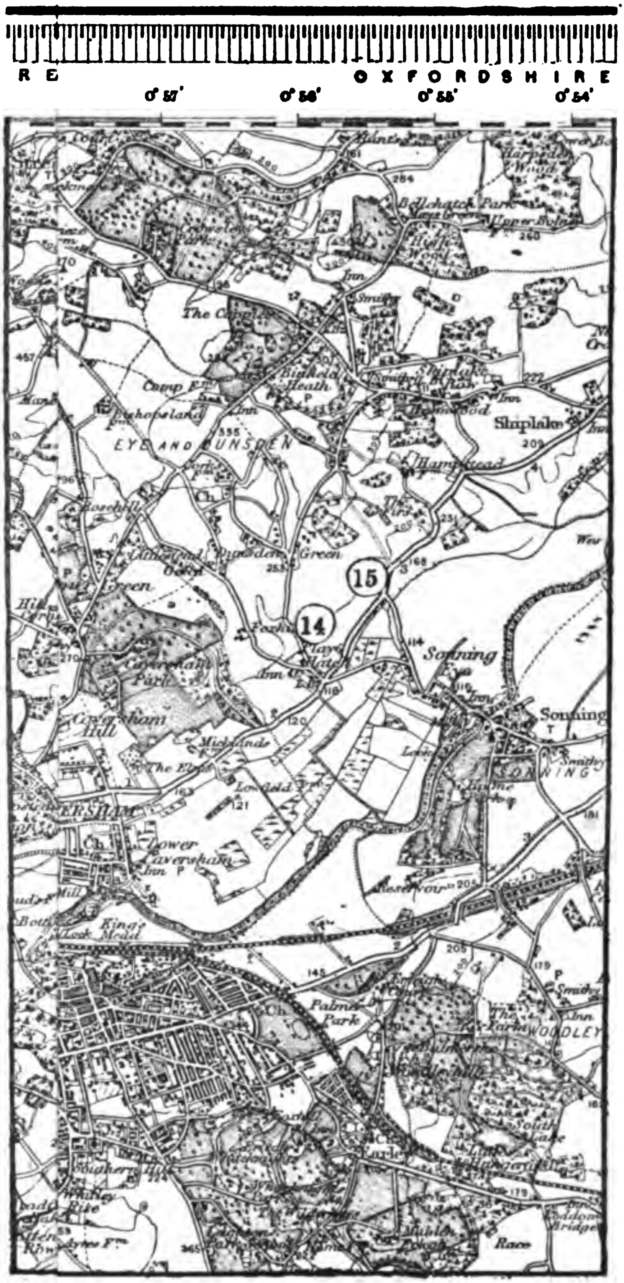
Pl XXIII



Pit No. 77^{c} at Brighstone Down (Central Mass).

F

PLATE XXIV.



PITS.

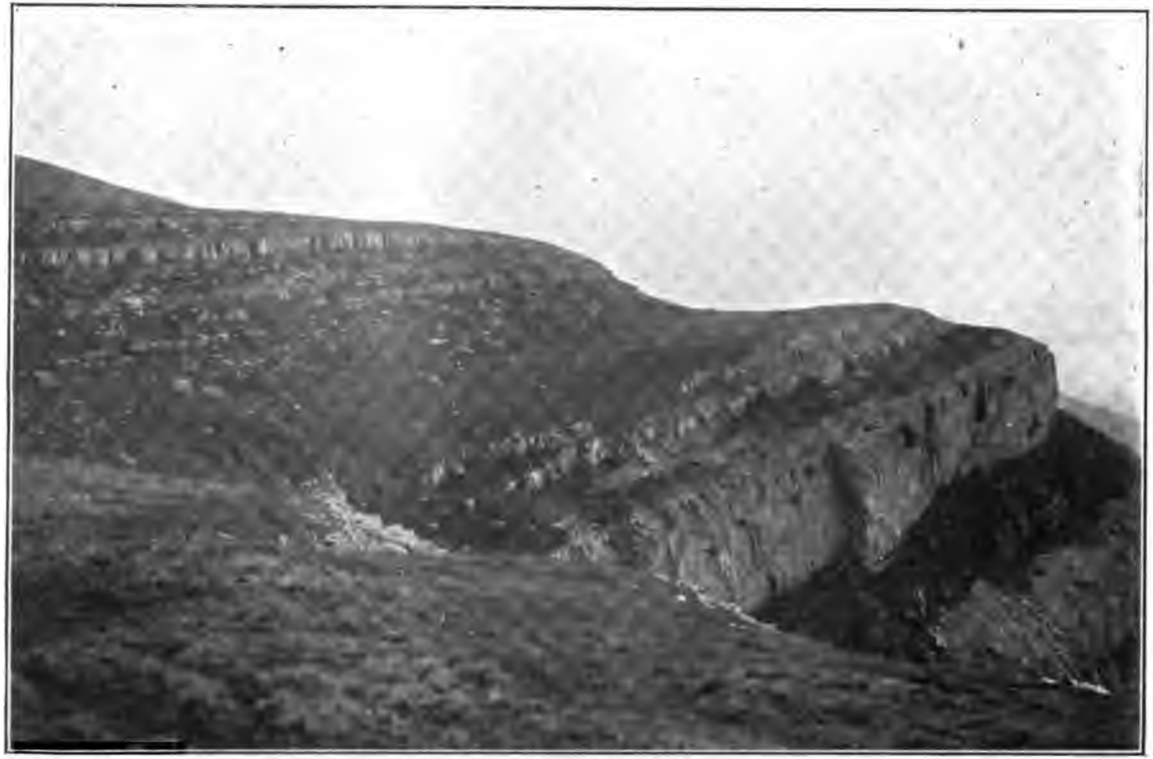


Photo by G. Bingley]

ESCARPMENT OF CARBONIFEROUS LIMESTONE, EGLWYSEG ROCKS NEAR LLANGOLLEN.

To face p. 478.

Plate XXVI.

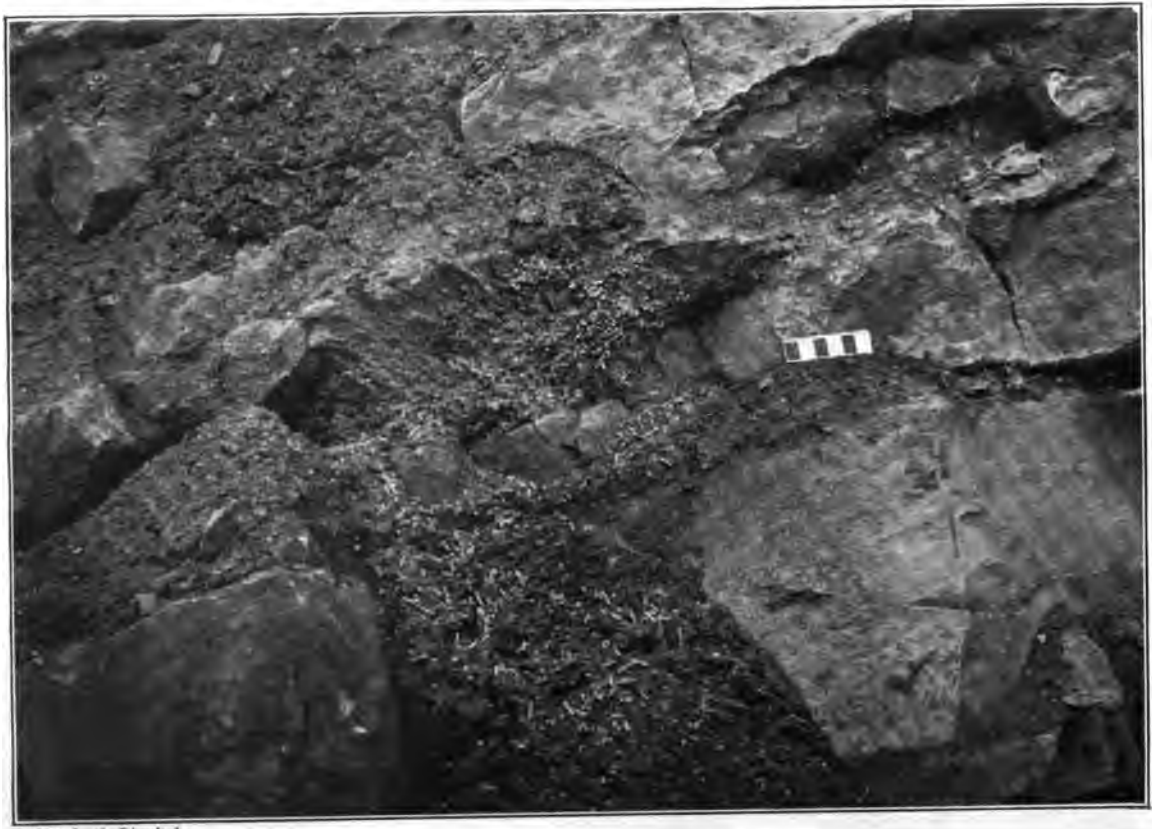


Photo by G. Bingley]

Carboniferous Limestone, Craignant Quarry.

To face p. 486.

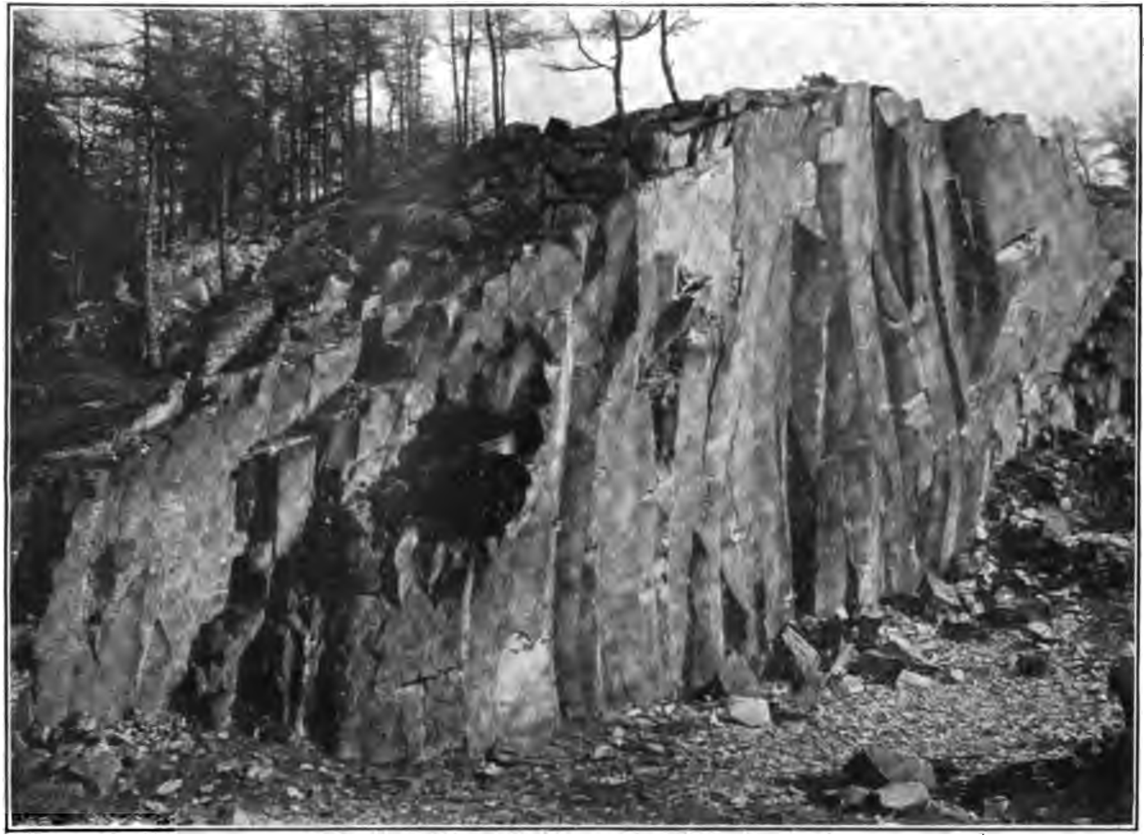


Photo by G. Bingley]

QUARRY IN "CHINA STONE" (CRAIG-Y-PANDY ASH). CAE DEICWS, LLANSANTFFRAID-GLYN-CEIRIOG.

SEC

ECKHAM

CHE

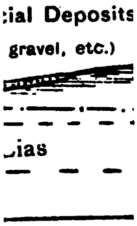


Fig.

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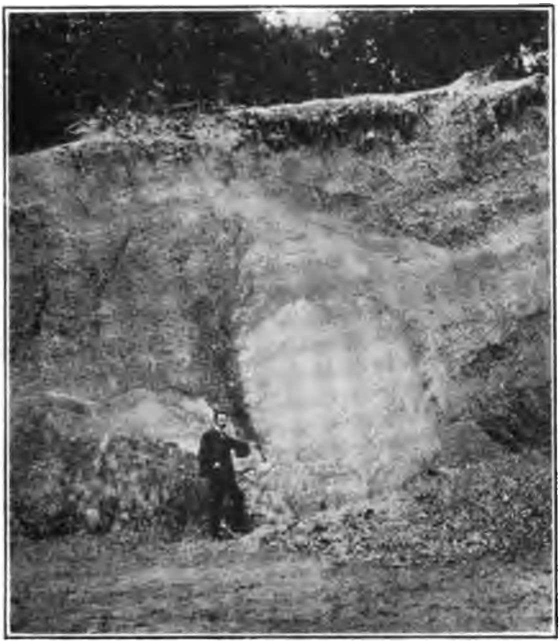

Photo by R. H. Chandler]

A MASS OF DISINTEGRATED FLINT PEBBLES IN BLACKHEATH BEDS, KNOCKMILL.